METALLURGIA

THE BRITISH JOURNAL OF METALS

Vol. 51 No. 305 MARCH, 1955 Monthly TWO SHILLINGS

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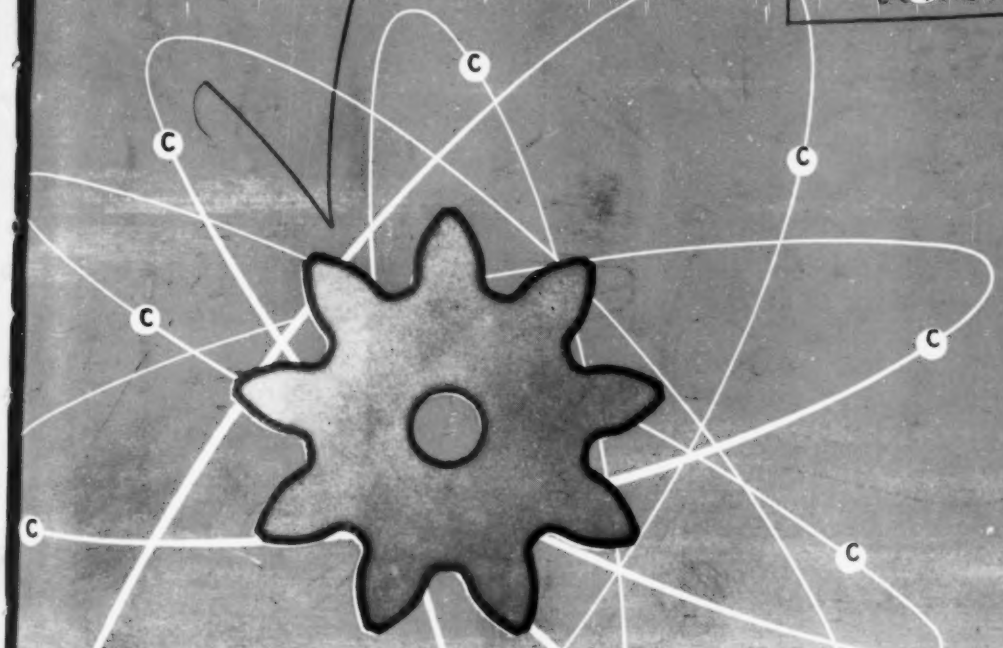
DEPOT

Wild-Barfield Gas Carburising is best of all



Gaseous Atmosphere for Carburising

Wild-Barfield developed the well-known 'P.T.G.' method of creating an effective carburising atmosphere from raw town's gas and this has been their standard process for the past twelve years.

Where capital outlay must be restricted to the minimum, however, or where space considerations are important, the new Wild-Barfield Drip Feed carburising process gives comparable results at no greater cost. The 'Carbodrip' liquid used in this method was evolved by the research department of Wild-Barfield—and gives *the same carburising atmosphere* as prepared town's gas.

Standards of finish and times of processing are comparable in both cases —so for *your* carburising needs consult Wild-Barfield, who will gladly advise you on the suitability of either process to your requirements.

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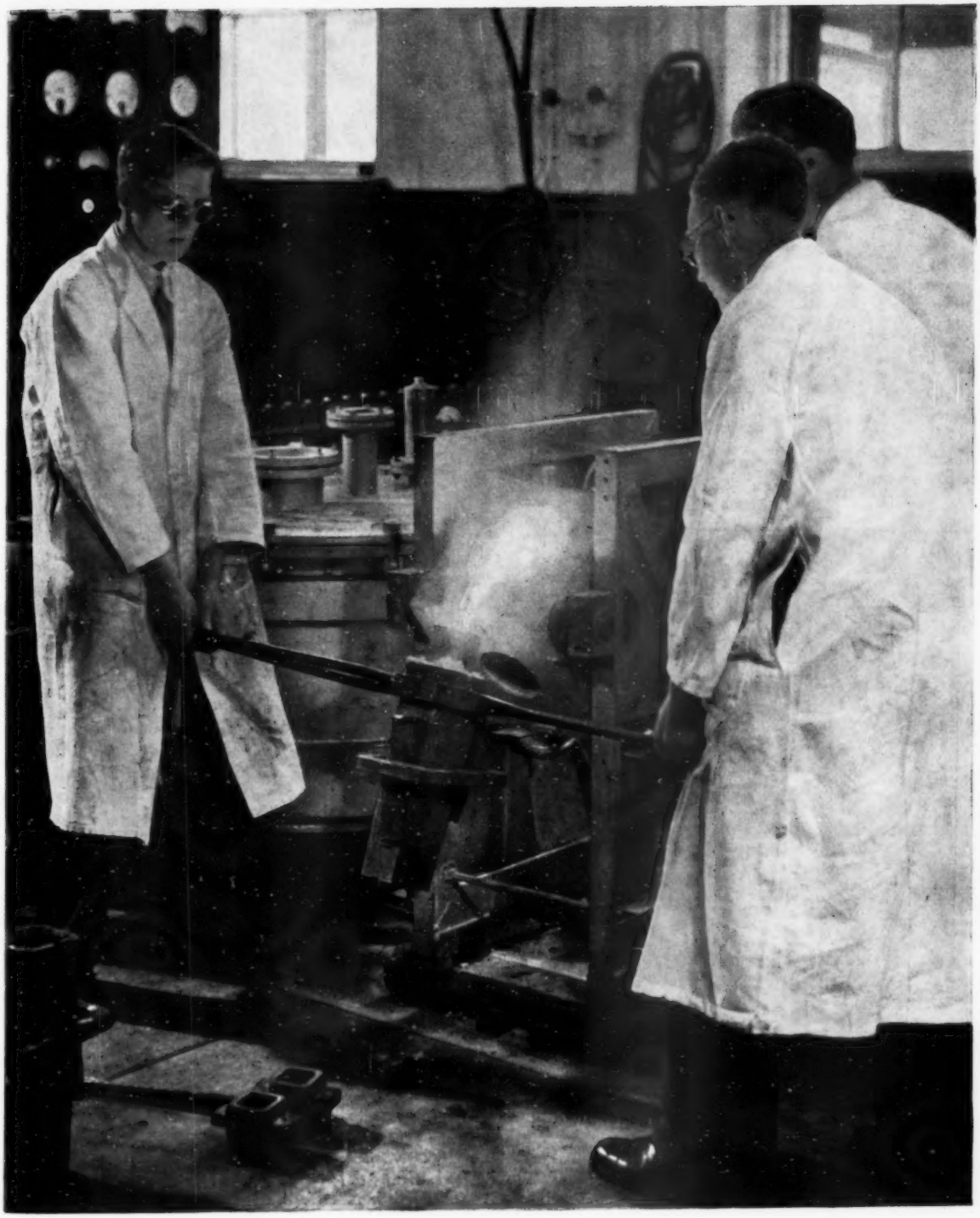

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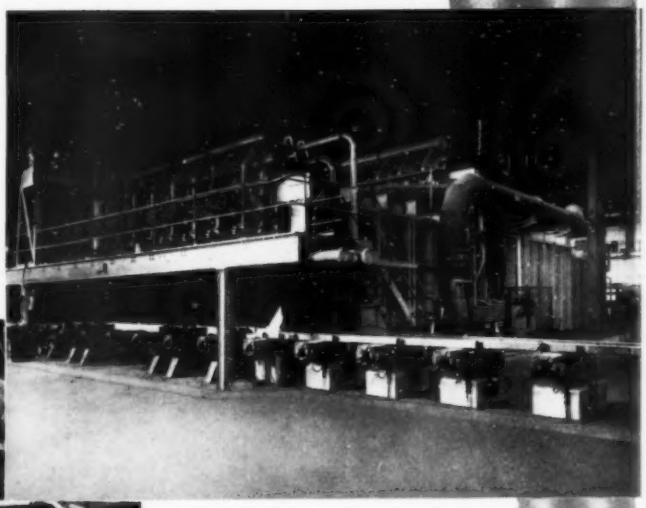

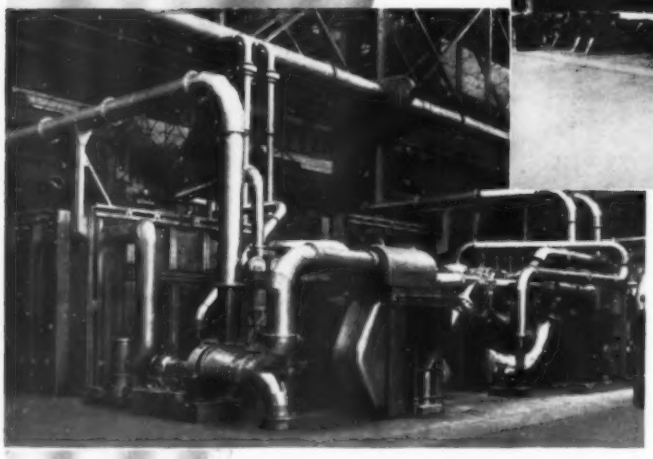

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To carry out the predetermined demands of the metallurgist, the modern furnace must exact a high degree of control.

Priest Furnaces are designed to afford precision control, uniformity of temperature, low fuel consumption, and long life with a minimum of maintenance.

Illustrated above are two recent Priest installations; the one on the left showing part of the heat treatment plant at the new Heavy Forge of Messrs. Hadfields Ltd. and that on the right showing one of two Continuous Slab Reheating furnaces installed as part of the Strip Mill reconstruction scheme at the Corby works of Stewarts & Lloyds Ltd.

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F.33

Characteristic of British Craftsmanship is this handsomely worked pistol. Made in the 16th Century from steel and wood it is a fine example of the work of that period and can be seen in the Victoria and Albert Museum.

Britain is proud of her craftsmen; throughout the years their skilled workmanship has earned a reputation for Britain that is second to none. The historical associations of steel in England chronicled through the ages, show how dependent we have become upon its production. Today its manifold uses in industry and everyday life have become legion—civilisation itself is woven over a framework of iron and steel. Hallamshire high grade Alloy and Carbon steels are an integral part of Britain's traditional good name.

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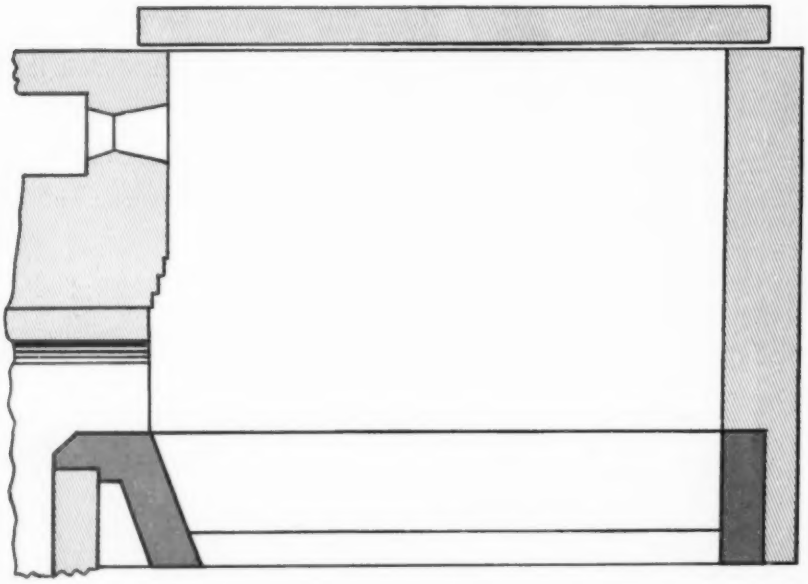

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Stein KM
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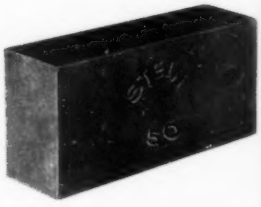

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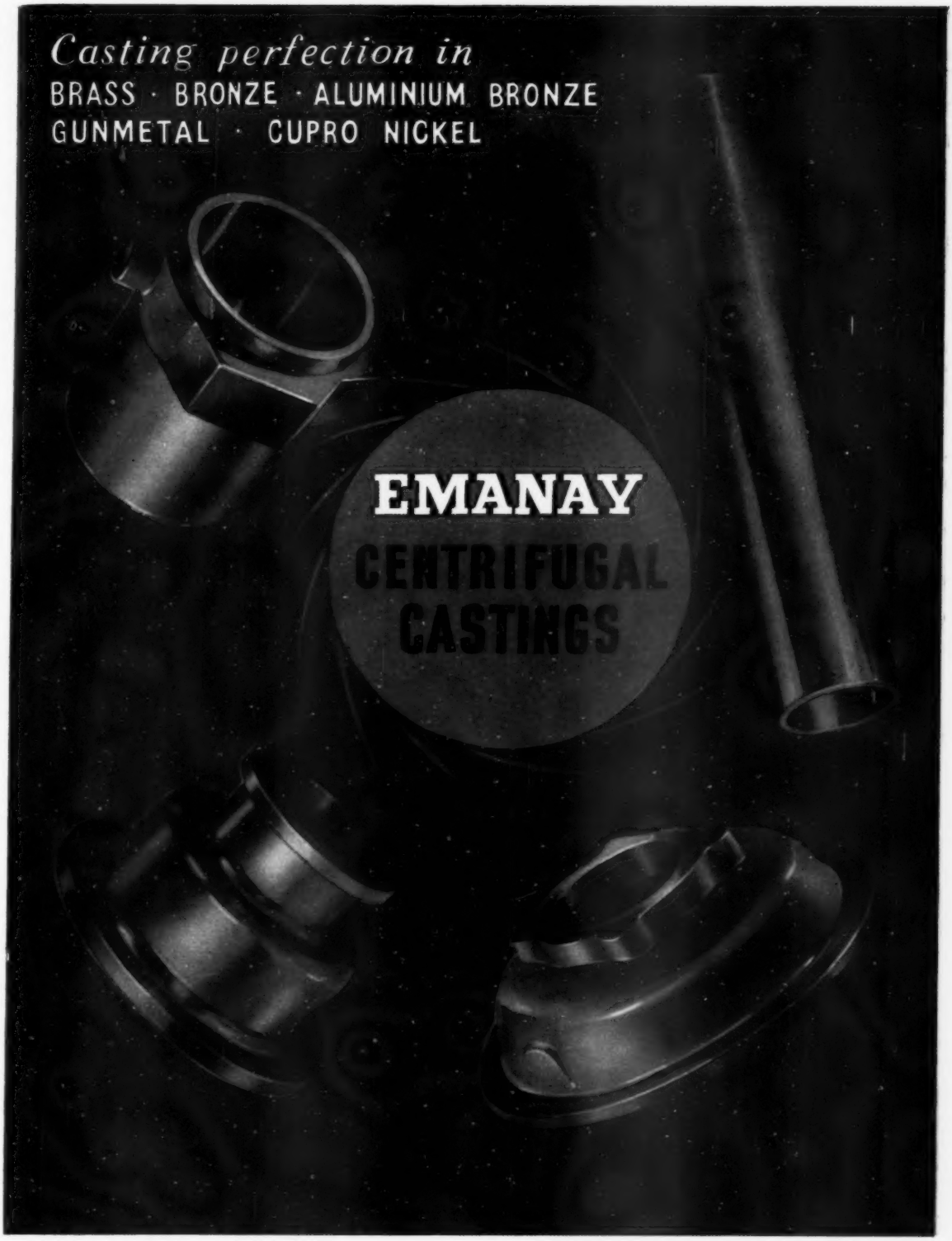

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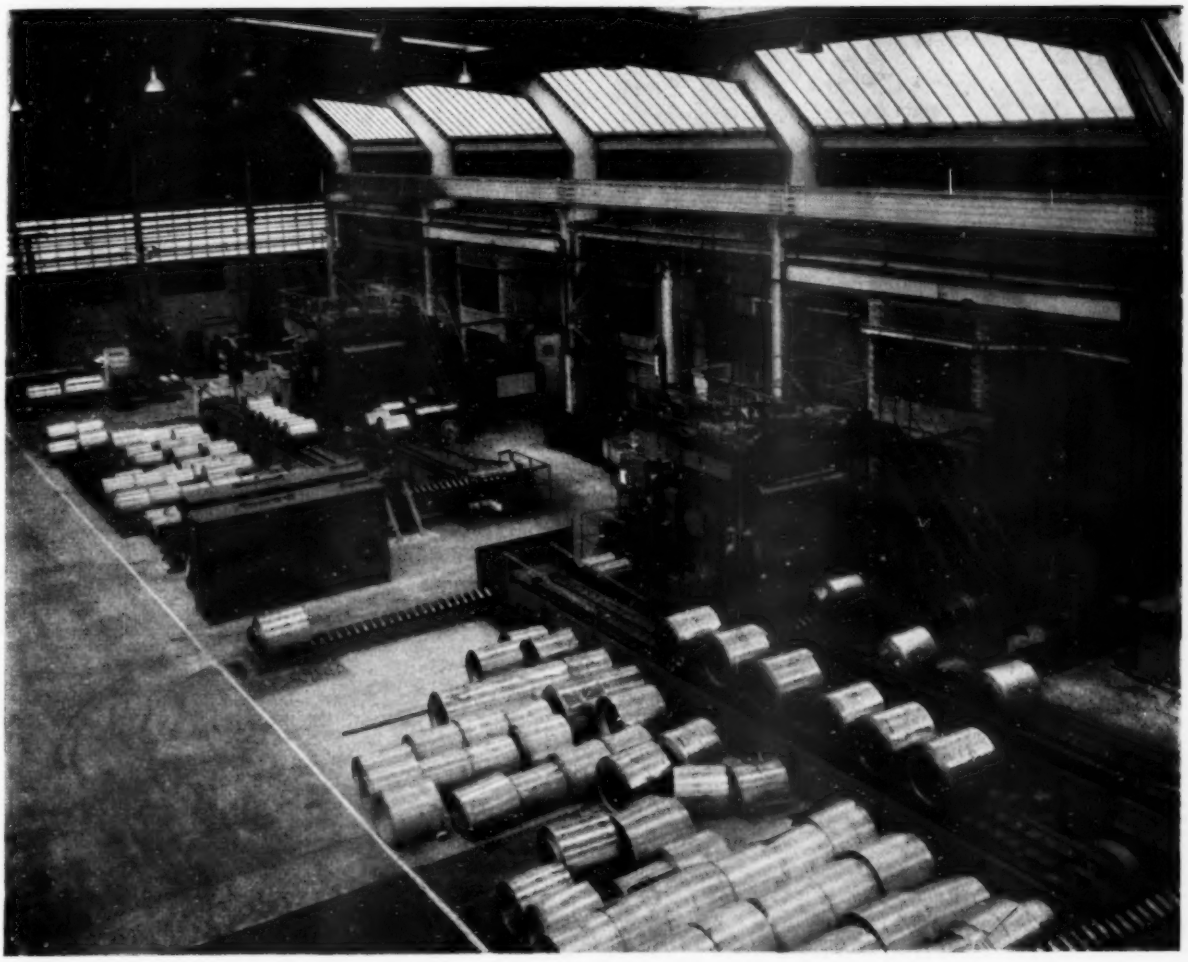


Two 32″ wide high-speed Cold Strip Mills for the rolling of copper and brass in coils, built for the Kynoch Works of Imperial Chemical Industries Limited, Metals Division, for whom a 36″ wide Cold Intermediate Mill has also been supplied.

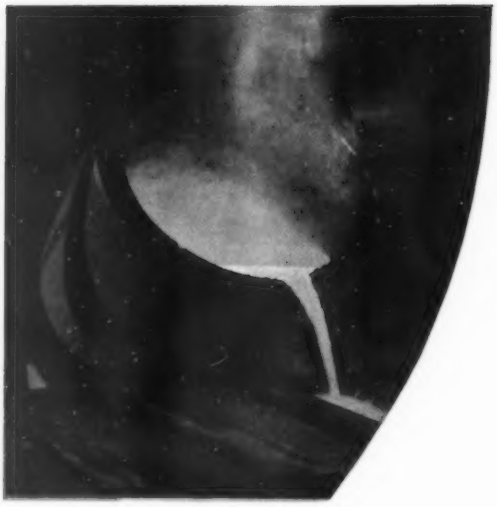
DAVY-UNITED

SHEFFIELD · MIDDLESBROUGH · GLASGOW

"Have you heard the story . . .

of the third link in the chain, which asked its next fetter to slacken its grip a little, and the next link asked its neighbour to loosen off a bit . . and so on, until the last link took its marching orders and filed off completely — leaving somebody's product to drop with a clang!

It just shows you how careful you must be these days to have your metal free from blemish. Of course, *you* already get better metal (and less rejects). You have a lower metal loss too, don't you? And accurate temperature control and exact alloy specification. Yes, but then *you* already know about



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the Morgan way

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ROBERTSON

Photograph by courtesy of The Enfield Rolling Mills Ltd., Brimsdown, Enfield

The photograph shows a reversing four-high cold mill for the production of brass and copper strip up to 26 in. wide

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. . . for accurate high-speed CONTROL of TEMPERATURES

THESE instruments operating on the Electronic principle are made in England for sale throughout the world by the Ether organisation. They were originally developed by the Wheelco Instrument Company of Chicago U.S.A., and are made by arrangement with them. Over 50,000 of these instruments have been sold and are in use all over the world. The whole of the technical progress and "know-how" possessed by Wheelco has been made available to Ether, who themselves have been engaged in the manufacture of Electronic equipment for the last 24 years. The combination of the two companies has produced instruments of unexcelled technical and mechanical construction.

Fig. 1

Ether-Wheelco "Capacitrol" Automatic Temperature Controller

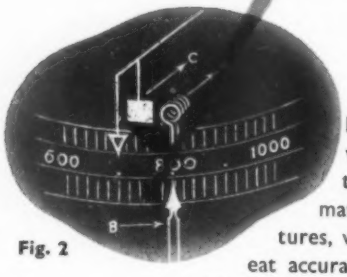

Fig. 2

Fig. 2 shows the way in which the science of electronics is used to automatically control temperatures, with the speed of light, eat accuracy and no interference with the measuring system. A light aluminium flag "C" passes between two coils "A" of the electronic system, when the flag enters the sphere of influence of the coils a movement of a few thousandths of an inch is sufficient to switch the control system off and on. By moving the coils attached to the pointer "B" the control position can be readily adjusted.

Fig. 1 (above) shows the "CAPACITROL" Automatic Temperature Controller capable of controlling electric, gas and oil-fired furnaces and apparatus utilising the On-Off or By-Pass system of control.

Other types are made giving two position and proportional control. These are known as the "MULTRONIC" and "PROPORTIONAL CAPACITROL."

All these instruments utilise electronics to automatically control temperatures with the speed of light, great accuracy and no interference with the measuring system. They are faster, simpler and more accurate than the Chopper Bar type formerly used. Send for descriptive List No. 250.

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THE STEEL COMPANY OF WALES LIMITED — SHEET & COIL BRIGHT ANNEALING PLANT

Photograph by courtesy of The Steel Company of Wales Limited.
Coils of sheet strip up to 74" wide are being annealed in these furnaces.

installed by INCANDESCENT

This plant, which now consists of 17 furnaces and 48 bases, is undergoing further extension and will eventually comprise 22 furnaces and 60 bases.

THE INCANDESCENT HEAT CO. LTD.

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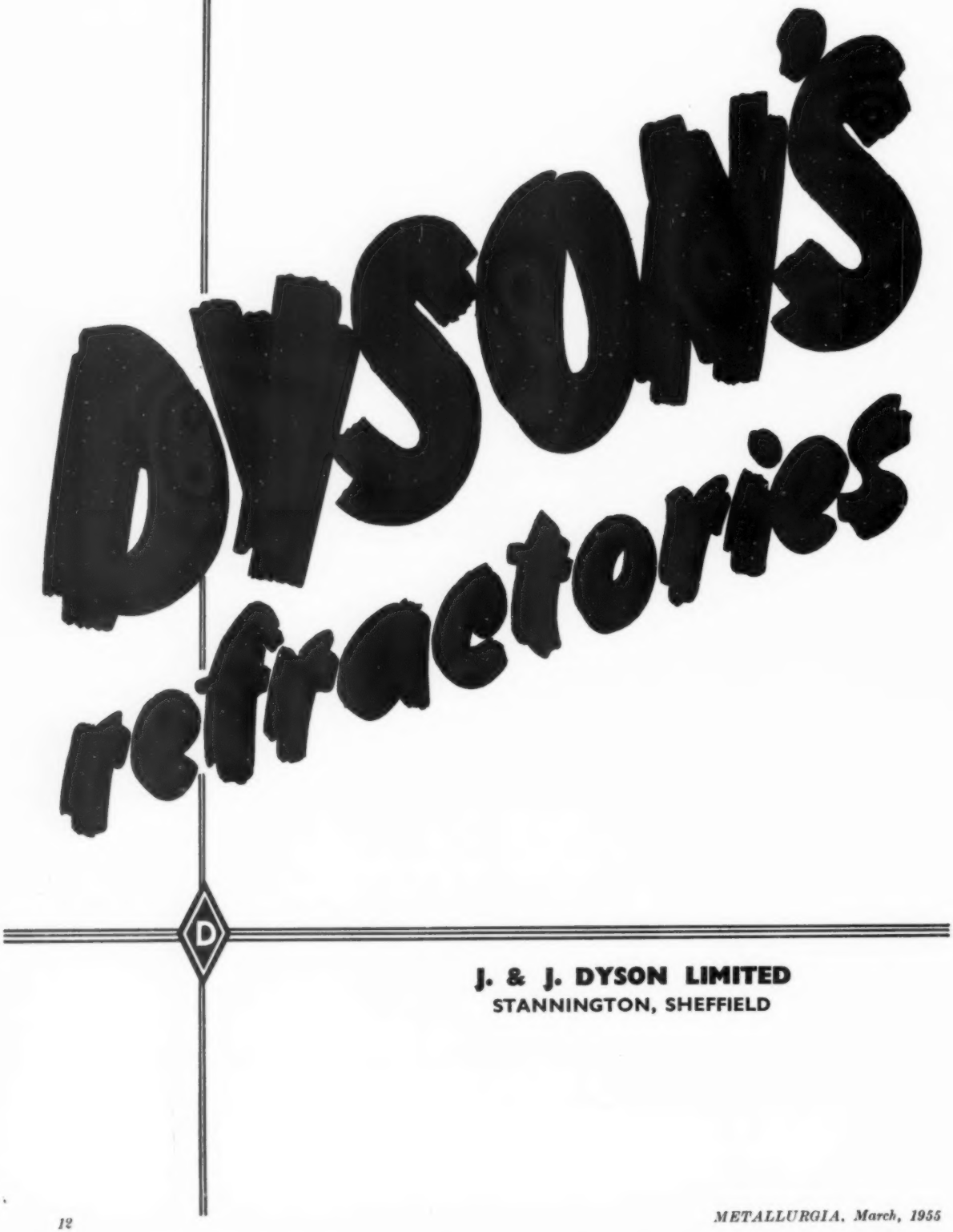
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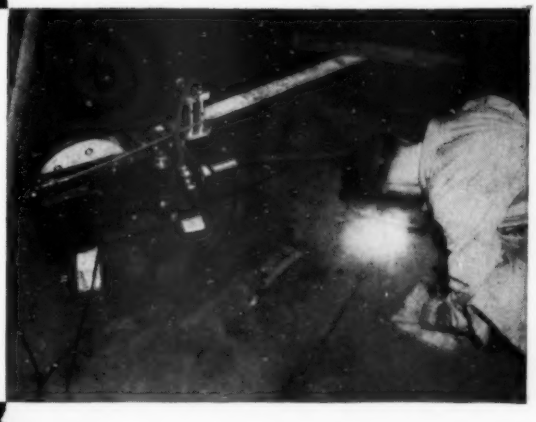
Here Argonaut is being used to weld a steel barge built by the Thames Steam Tug & Lighterage Co. Ltd. Butt welds on semi-killed boiler quality steel and fully-killed pressure vessel steel have been found to have a greater strength than the parent metal. For further details and full technical information write to your nearest B.O.C. Branch.



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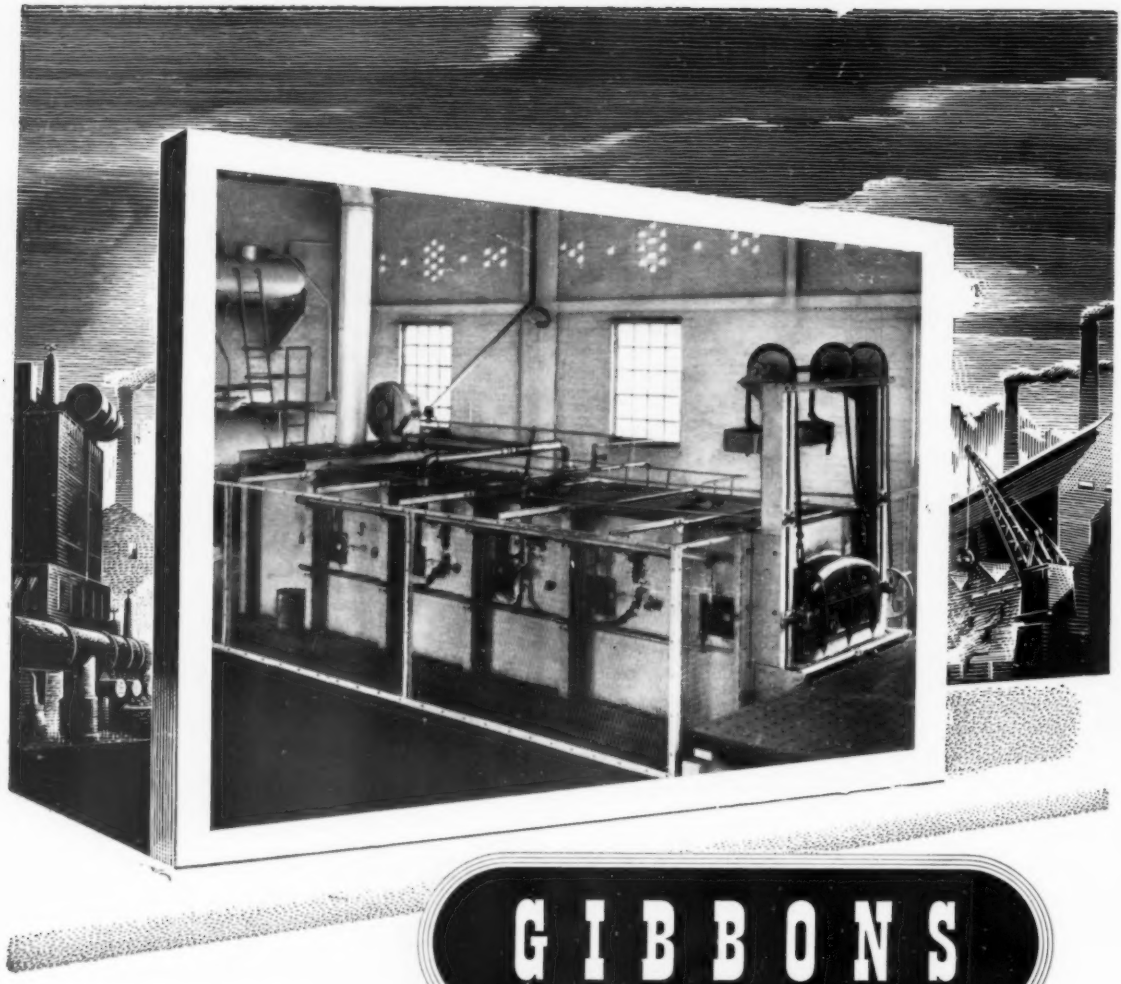

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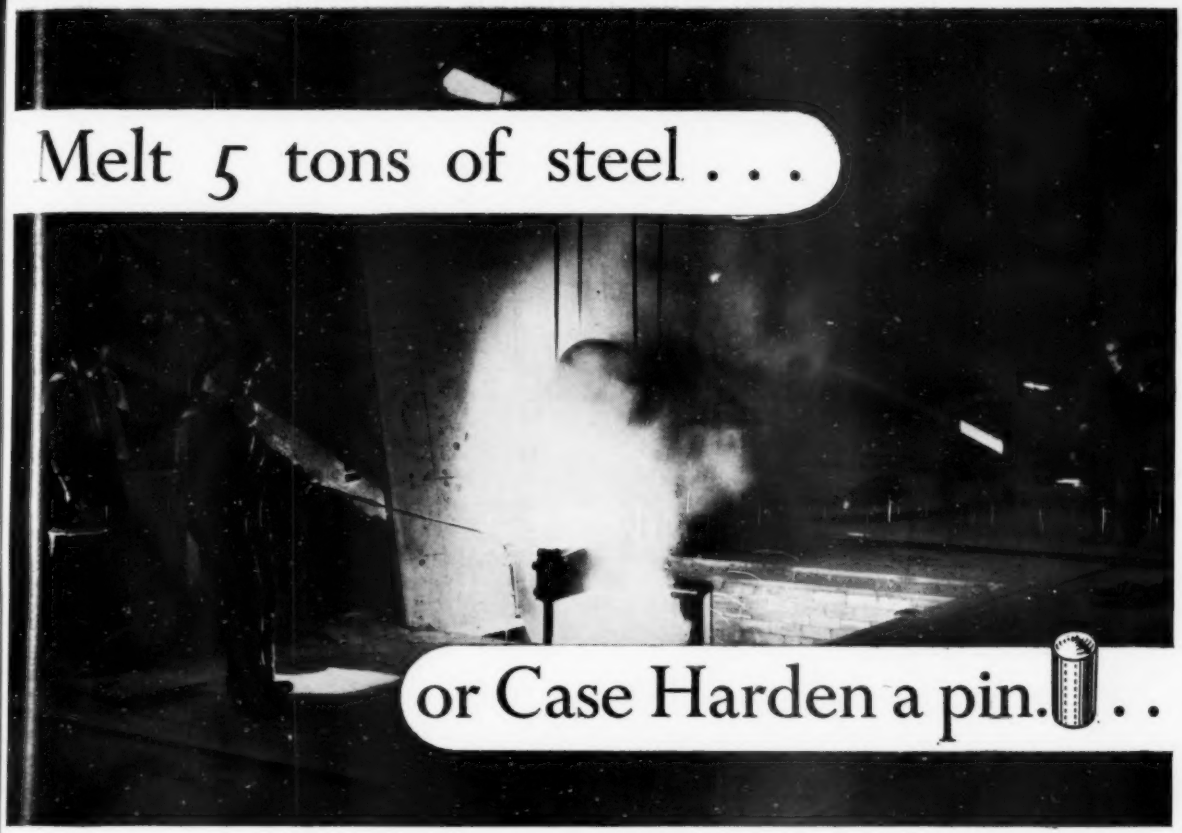

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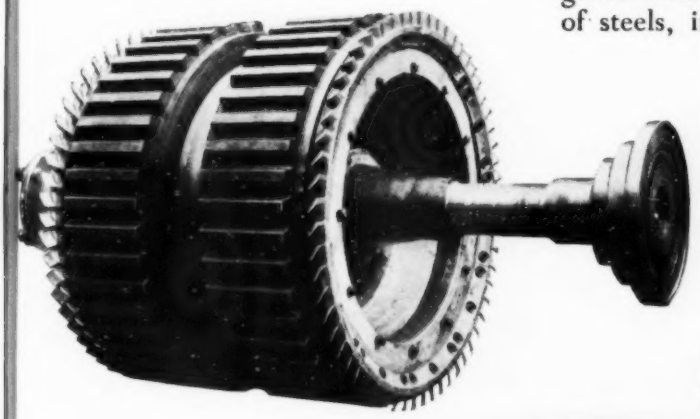

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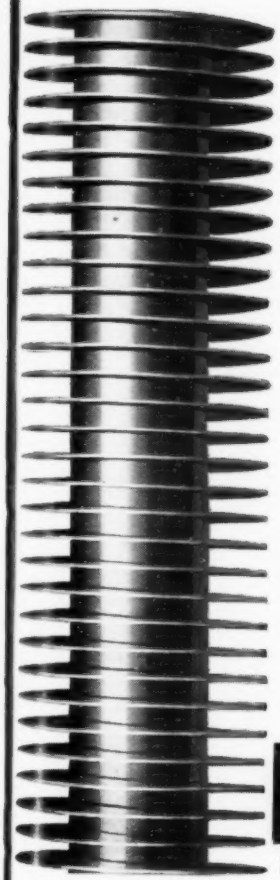
'INTEGRON' Integral finned tubing



'INTEGRON' is a finned tube in which the fins are cold-formed from, and integral with, the parent tube. Made in copper, aluminium and certain alloys of these metals, 'Integron' tubing offers the advantages of strength, compactness, corrosion resistance and good heat transfer properties.

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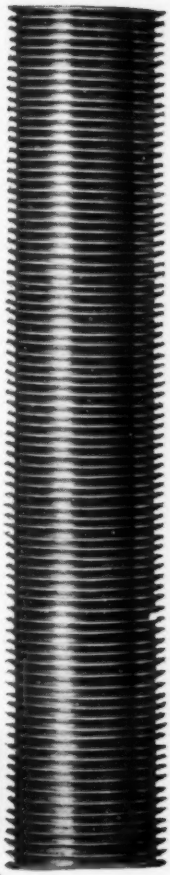
Literature available on request.



'INTEGRON' finned tubing

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

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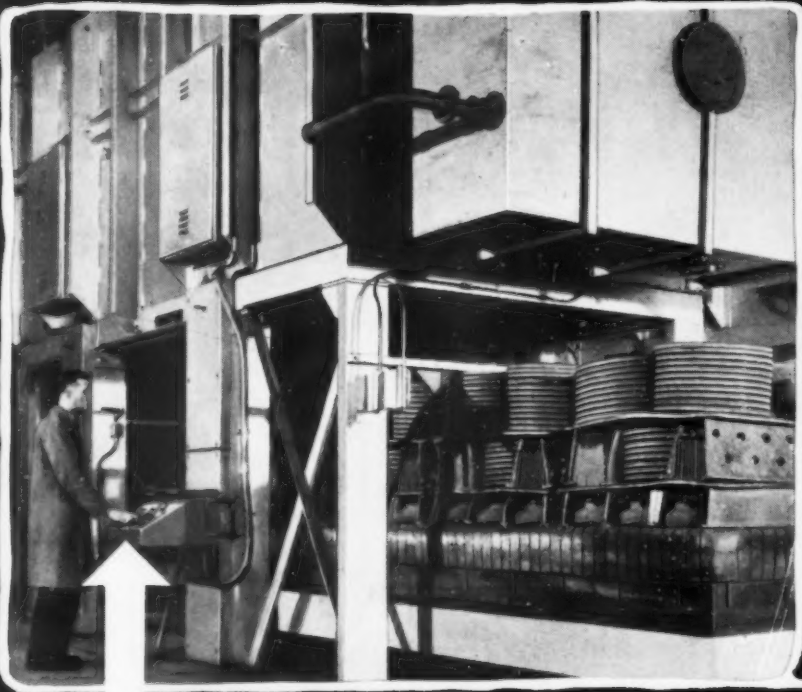

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The finger on the button, a slight movement — and into the furnace go five or more tons of castings. Like all iron castings they go in brittle, but after a cycle of heat, soak and slow cool in the controlled atmosphere, they come out malleable. Gaseous annealing in an electric furnace is quick and efficient — whereas conventional methods, involving packing in boxes, require much fuel, labour and materials. For consistent high quality in the product, for cleanliness in the works, and for low costs in the process, there is nothing like an electric annealing furnace — but it is

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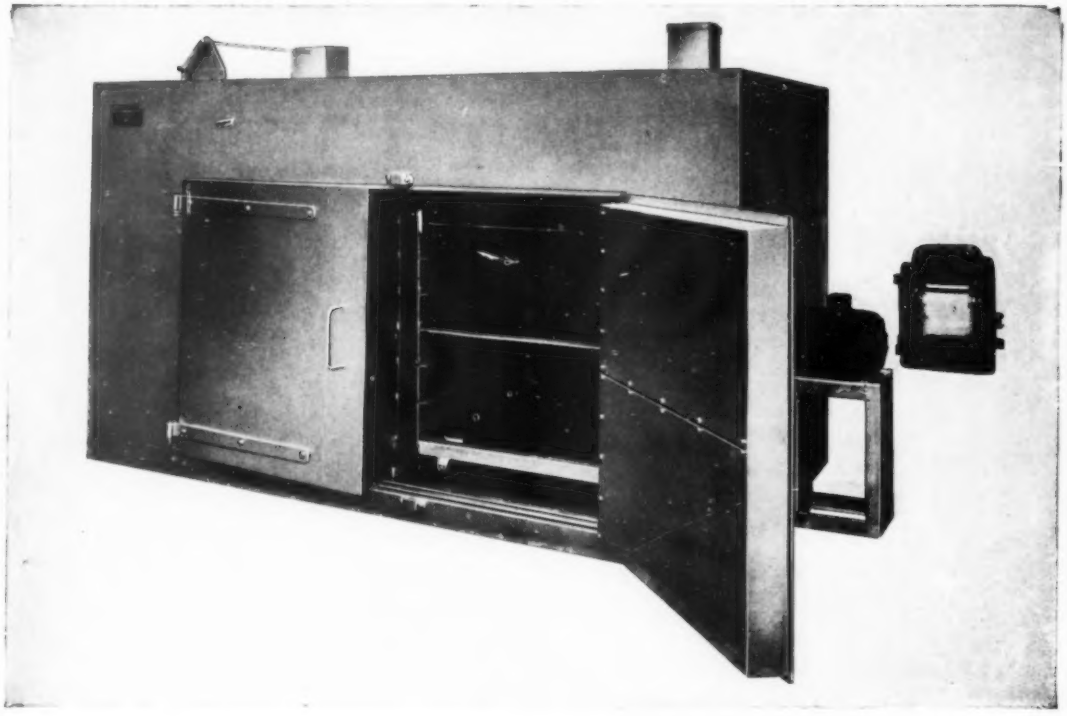

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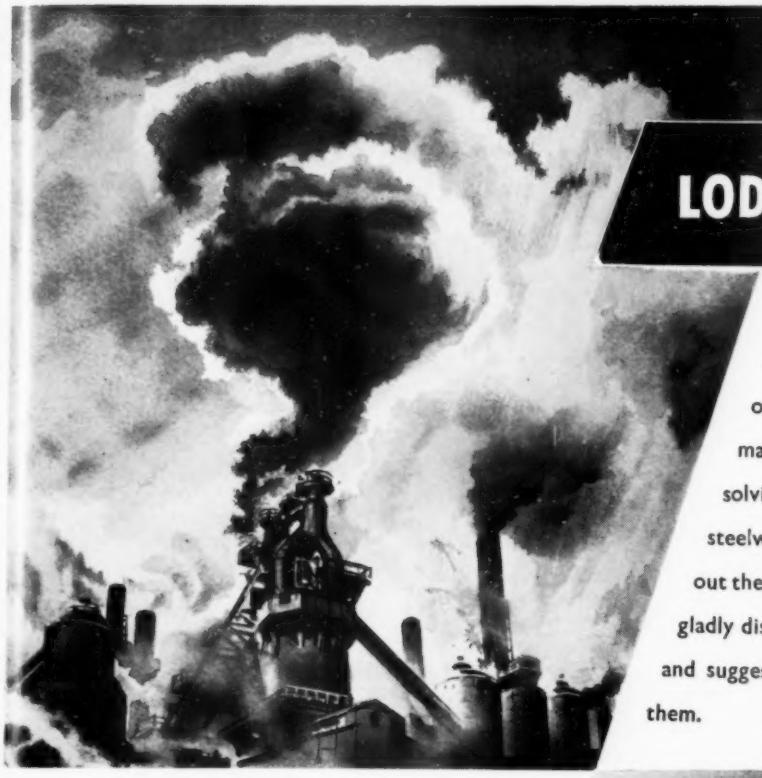

This Lodge-Cottrell Electrostatic Precipitation Plant at the Steel Company of Wales, Margam, is one of the many similar installations successfully solving dust and smoke problems in steelworks and blast furnaces throughout the world. Our Advisory staff will gladly discuss with you your problems and suggest the best way of solving them.

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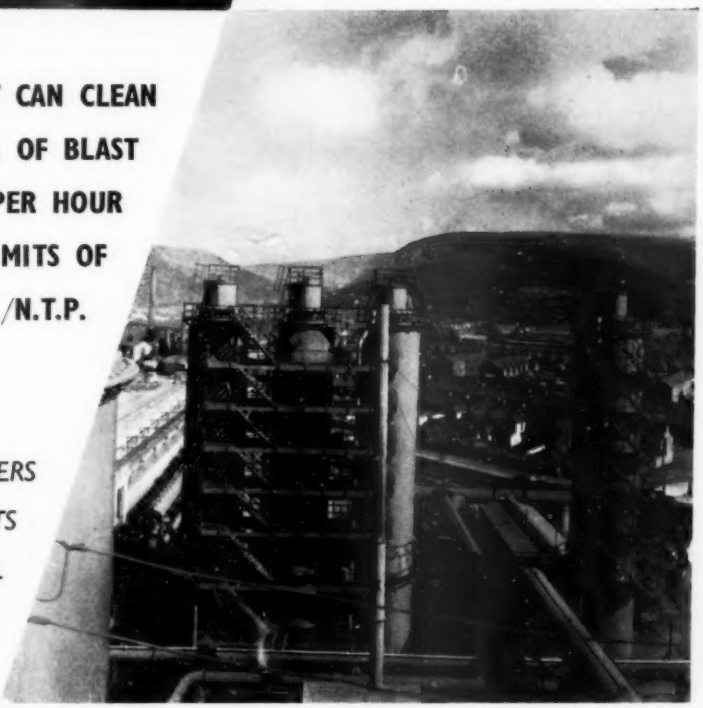

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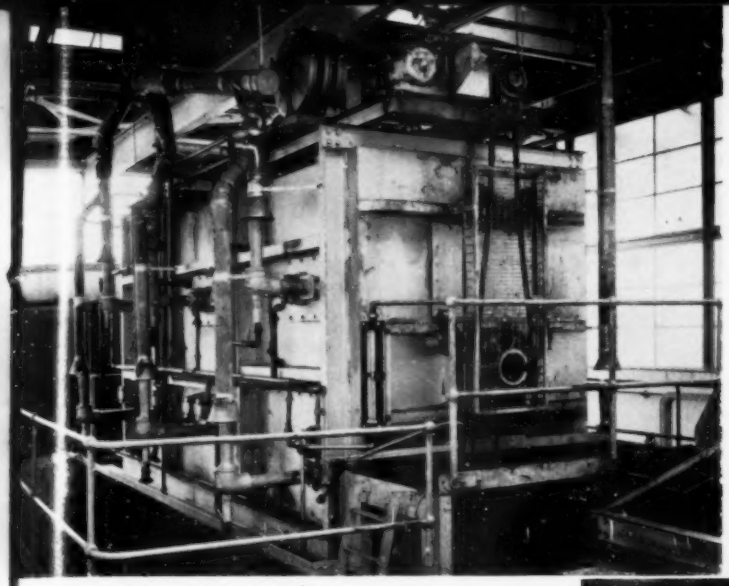

(1)

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FOR
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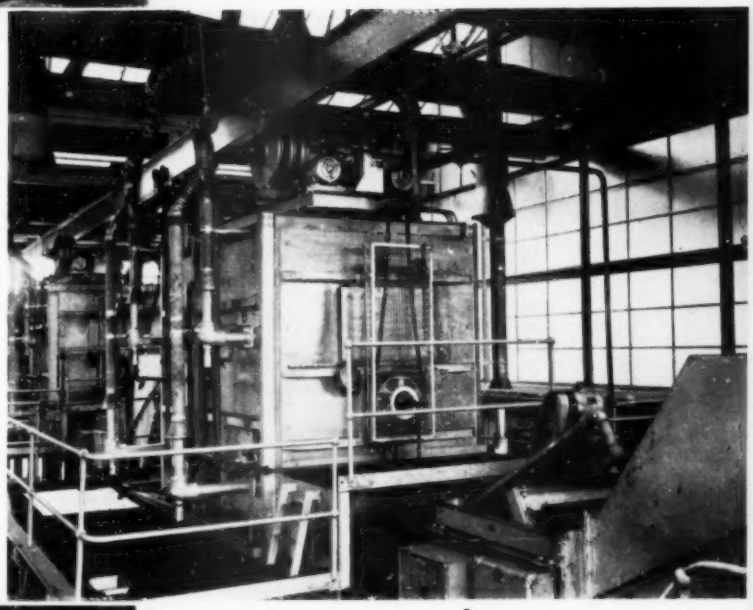
HIGH-PRODUCTION
HEAT TREATMENTS

(1) Discharge end of Rotary Retort Gas Carburising Furnace. After carburising the work is discharged automatically into the quench tank.

(2) Discharge end of Rotary Retort Controlled Atmosphere Hardening Furnace from which the work is again automatically quenched.

(3) Side view of Rotary Retort Tempering Furnace of the Recirculating Type. The work from this furnace is discharged into containers.



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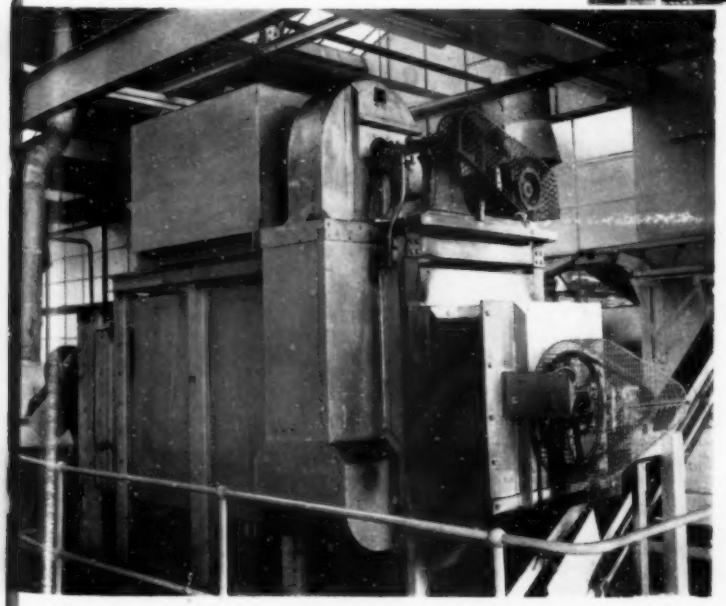

(3)

The illustrations show a straight-line production unit for the following operations, Carburise, Quench, Wash, Reheat, Quench, Wash, Temper in a fully automatic process.

BRITISH FURNACES Ltd.

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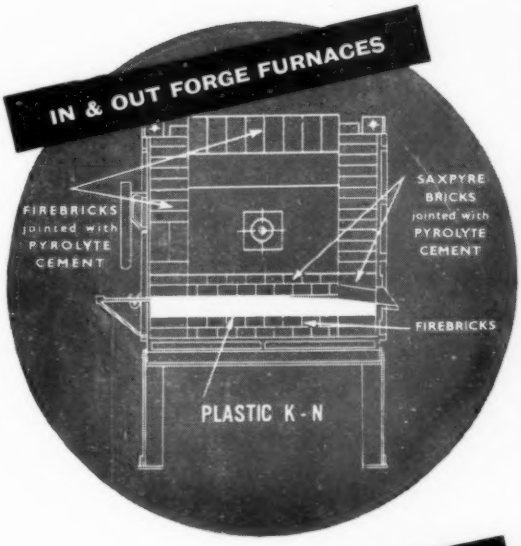

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- ✻ Permits slag and scale removal from hearth with minimum damage to refractory.
- ✻ Chemically neutral to other refractories.

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Offers a slag-resisting non-shattering surface highly resistant to physical shock. When banked up the side walls to form fillets, it prevents slag from penetrating to sub-hearth.

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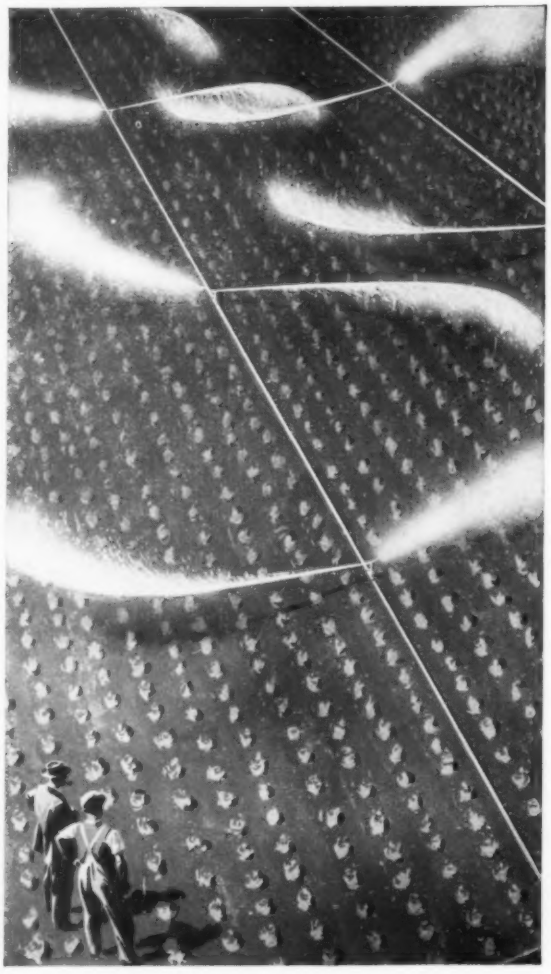
ALUMINIUM AT WORK



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Look into any kitchen. Count the aluminium saucepans and pressure cookers, pots and pans. Why aluminium? Because it is light, clean and easy to handle, yet stands up to hard everyday use. Because aluminium *likes* water, and does not deteriorate. Sound reasons, these, for putting aluminium to work in many other ways. Take irrigation equipment. Aluminium can now give the farmer and market gardener lightweight pipes and sprayers that will last a life-time with a bare minimum of care and attention. Just think, now—is aluminium working for you?

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GIBBONS "H·T 1"

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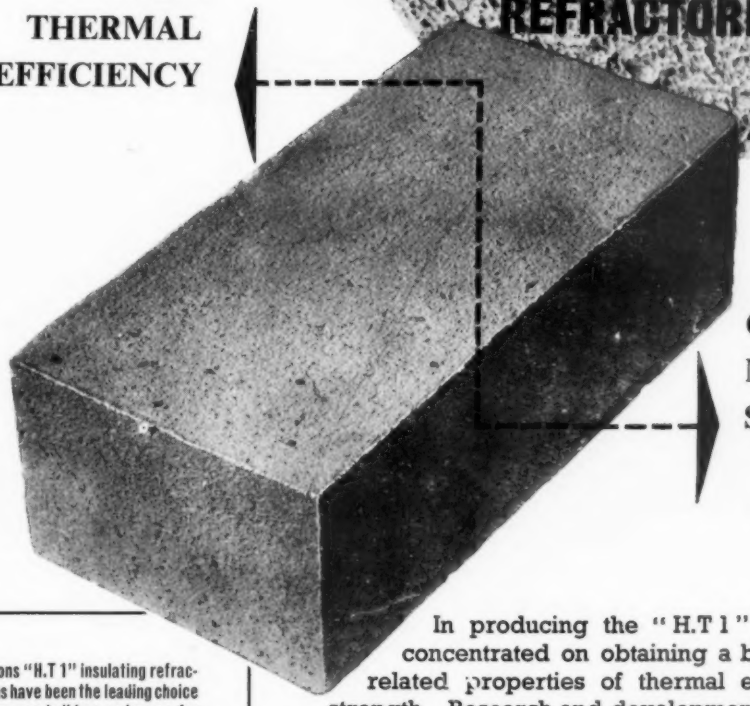

GREAT MECHANICAL STRENGTH

Gibbons "H.T 1" insulating refractories have been the leading choice of furnace builders and users for many years and represent today an unrivalled combination of physical properties and economy in price.

QUALITIES NOW IN PRODUCTION FOR SERVICE TEMPERATURES OF 1300°C—1500°C

In producing the "H.T 1" brick efforts have been concentrated on obtaining a balance between the inter-related properties of thermal efficiency and mechanical strength. Research and development work has resulted in the evolution of entirely new manufacturing methods whereby high insulating value and low heat storage capacity have been attained with an exceptionally high mechanical strength.
Furnace Builders will appreciate the strong even texture of these new "H.T 1" bricks which can easily be cut, sawn or drilled on the job and repeatedly handled without costly waste resulting from crumbling corners and breakage.

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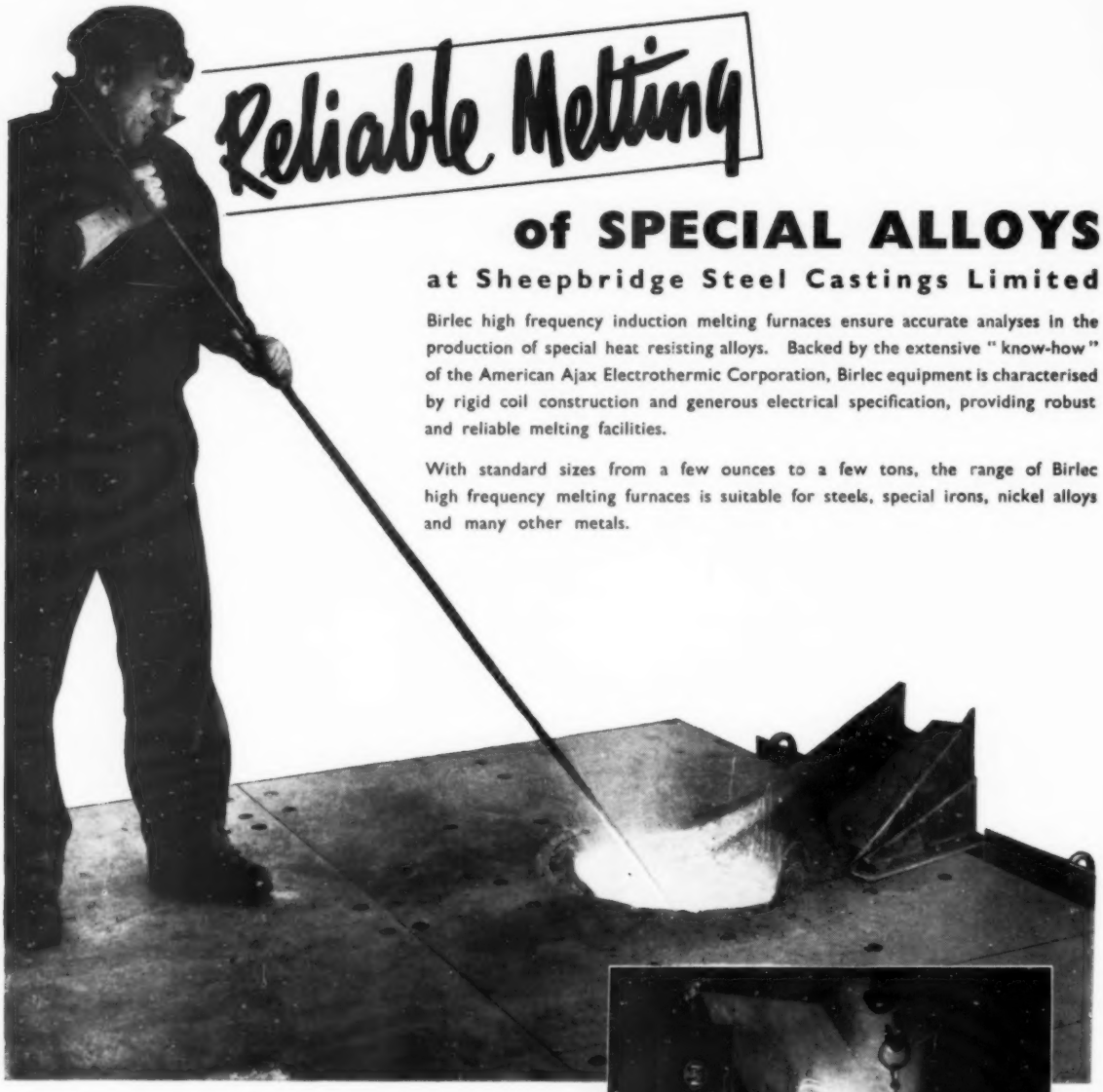
of SPECIAL ALLOYS

at Sheepbridge Steel Castings Limited

Birlec high frequency induction melting furnaces ensure accurate analyses in the production of special heat resisting alloys. Backed by the extensive "know-how" of the American Ajax Electrothermic Corporation, Birlec equipment is characterised by rigid coil construction and generous electrical specification, providing robust and reliable melting facilities.

With standard sizes from a few ounces to a few tons, the range of Birlec high frequency melting furnaces is suitable for steels, special irons, nickel alloys and many other metals.



Above: one of the two 10 cwt. furnaces at Sheepbridge Steel Castings Ltd. The furnaces are powered by a 400kW high frequency motor alternator generator which is connected to either furnace through a change-over switch.

Inset top: pouring one of the furnaces; hydraulic tilting mechanism is used.

Inset bottom: the furnace platform showing control desk and instrument panel.

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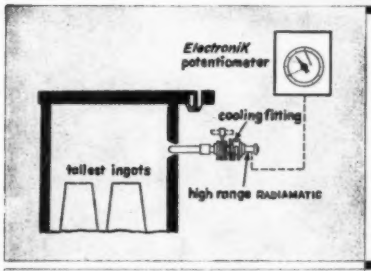
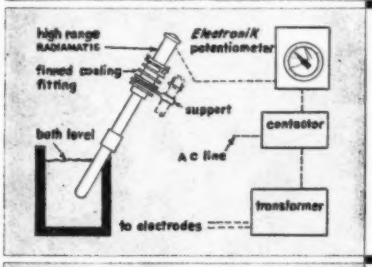
typical applications of BROWN RADIAMATICS



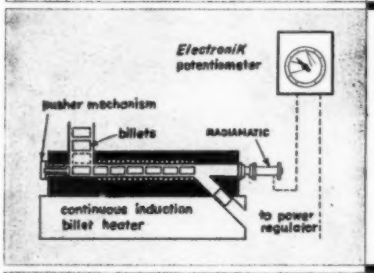
soaking pits

The Radiamatic may be used on either regenerative or recuperative soaking pits. For this service, the Radiamatic is sighted into a closed end sillimanite tube which is located so as to be responsive to the average temperature of the ingots. The Radiamatic, being unaffected by vibration and wide changes in the ambient temperature, is ideally suited for this severe service. Its high speed of response assures closer control.



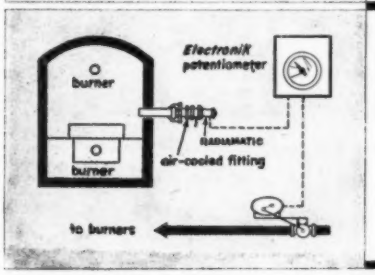
high-speed salt baths

Automatic control of high-speed salt baths from a Radiamatic measurement assures the ultimate in close temperature regulation, thereby increasing the output of properly heat-treated work. A Radiamatic and closed end sillimanite target tube assembly is installed on an electrically heated salt bath. As shown in the illustration, the sillimanite target tube is immersed 4 to 6 inches into the bath and the Radiamatic sights on the closed end of the tube. A support fitting and adjustable clamp facilitate mounting the assembly, and the finned cooling fitting adequately protects the Radiamatic from overheating.



induction heating for forging

In induction heating for forging, the Brown Radiamatic is sighted on the work in direct line with the axis of the inductor coil of continuous billet heaters. Many factors, such as work speed, power input and frequency variations, determine work temperatures. Thus the Radiamatic, which provides the actual billet temperature, can be used with a temperature controller to actuate work speed, or power input regulators to obtain the desired billet temperature. The Radiamatic can also be used effectively with many other forms of induction heating where the target area and heating cycle permit.



forging furnaces

When used to measure forging furnace temperatures, the Brown Radiamatic is sighted into a closed end ceramic tube. The end of the tube is located so that a cold billet in the line will not unduly affect the temperature measurement, also so that the radiation it receives is principally from the walls of the furnaces and not from flame impingement. The Brown control system for forging furnaces consisting of Radiamatic, control instrument and motorized valves has numerous operating advantages.

Instrumentation data sheets available on request covering all applications of Brown Radiamatics.

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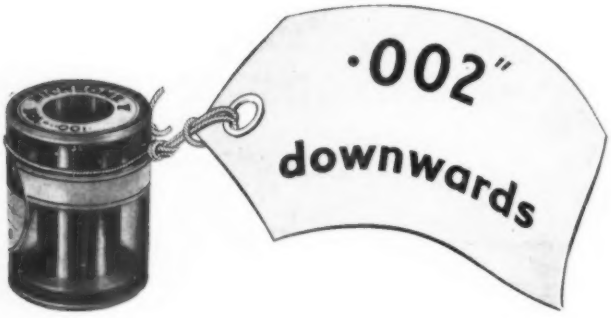

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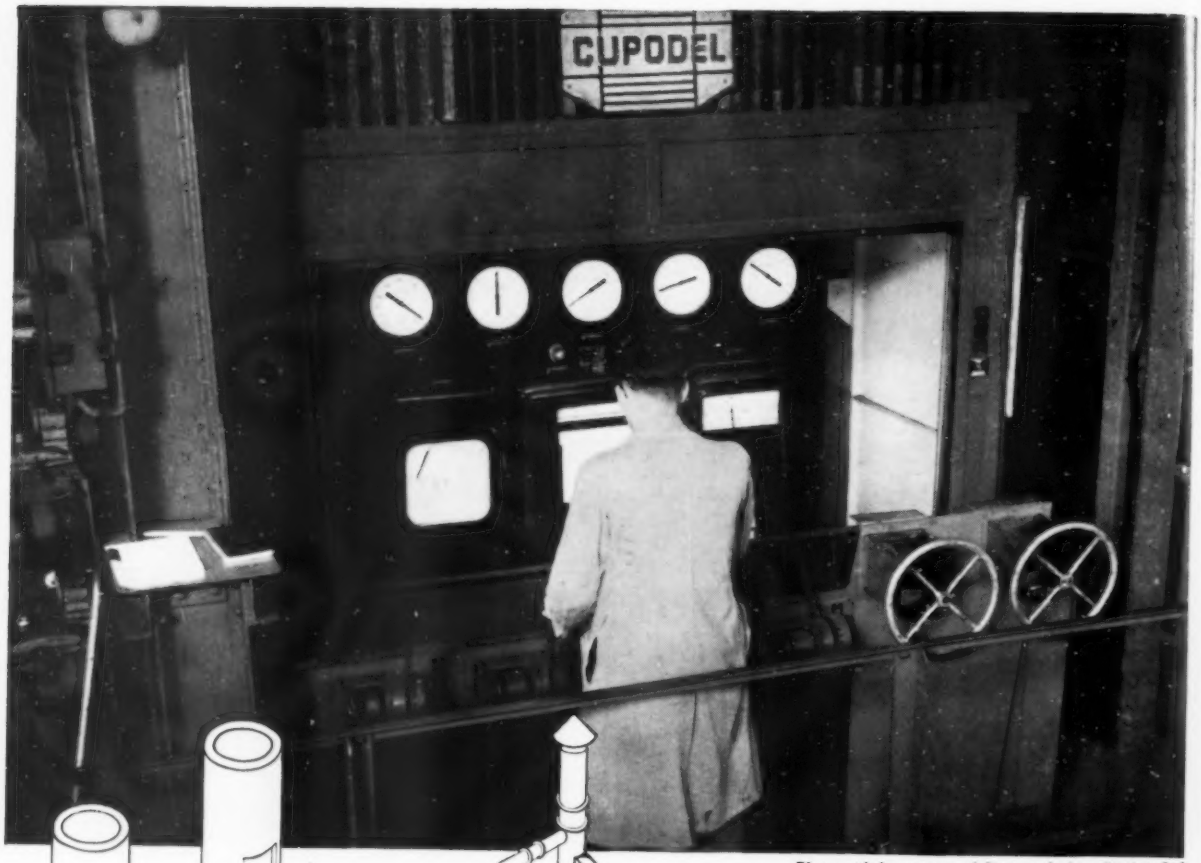

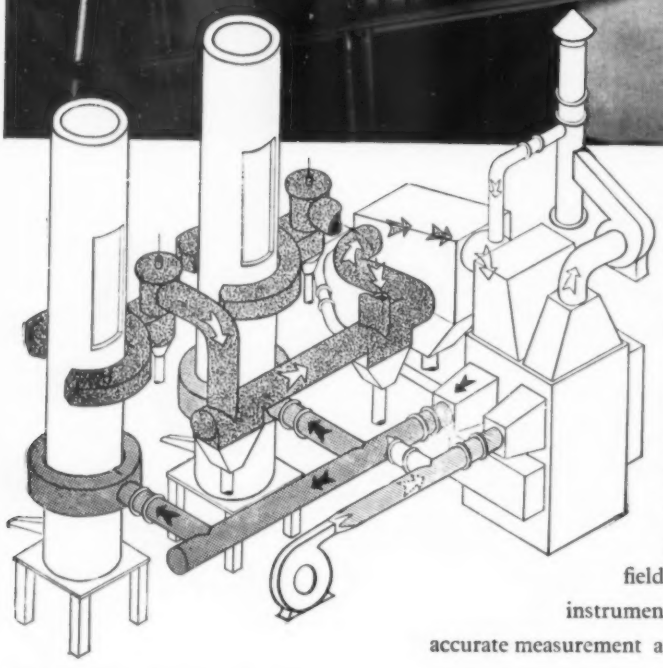

Photograph by courtesy of Dartmouth Auto Castings Ltd. and diagram by courtesy of Cupodel Ltd.

Hot Blast Control is a major factor in ensuring the economical production of pig iron in blast furnaces. In modern iron foundry practice, too, it is of equal importance in the reduction of iron in cupolas.

Cupodel Ltd., of London and Birmingham, have applied this principle, introducing regenerative heating into cupolas with resultant increases in productivity and savings in cost. The Elliott organisation, whose specialist engineers have many years experience of measurement and control in this field, have successfully co-operated with Cupodel in the instrumentation of a number of these installations, providing accurate measurement and control of temperature, flow, pressure and draught.

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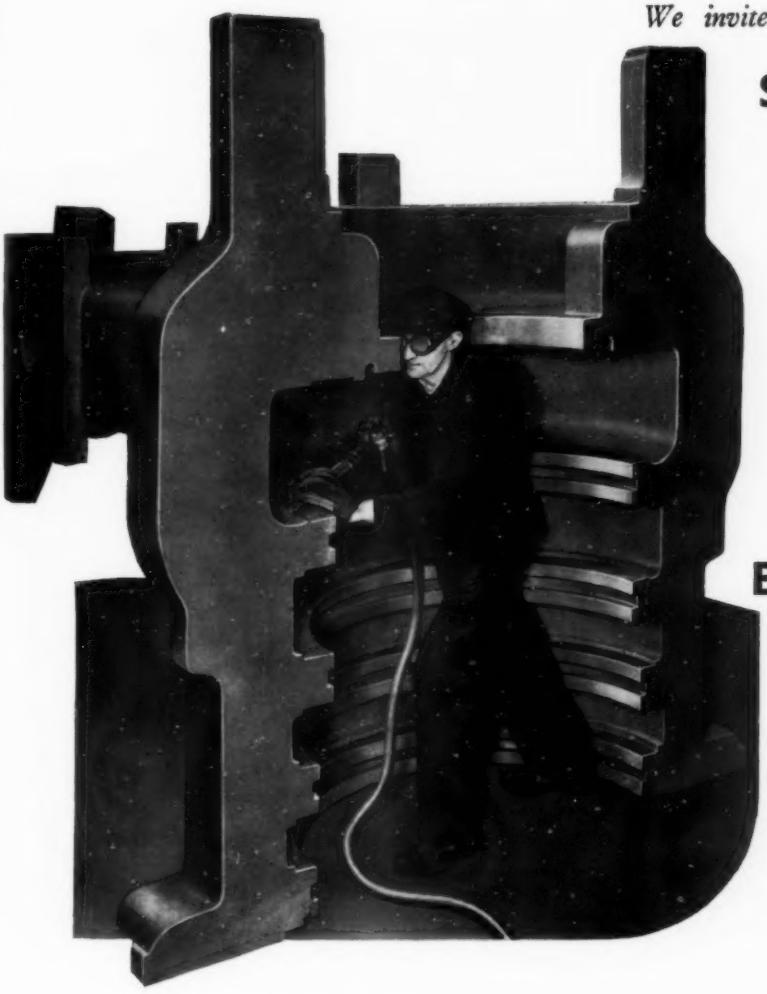

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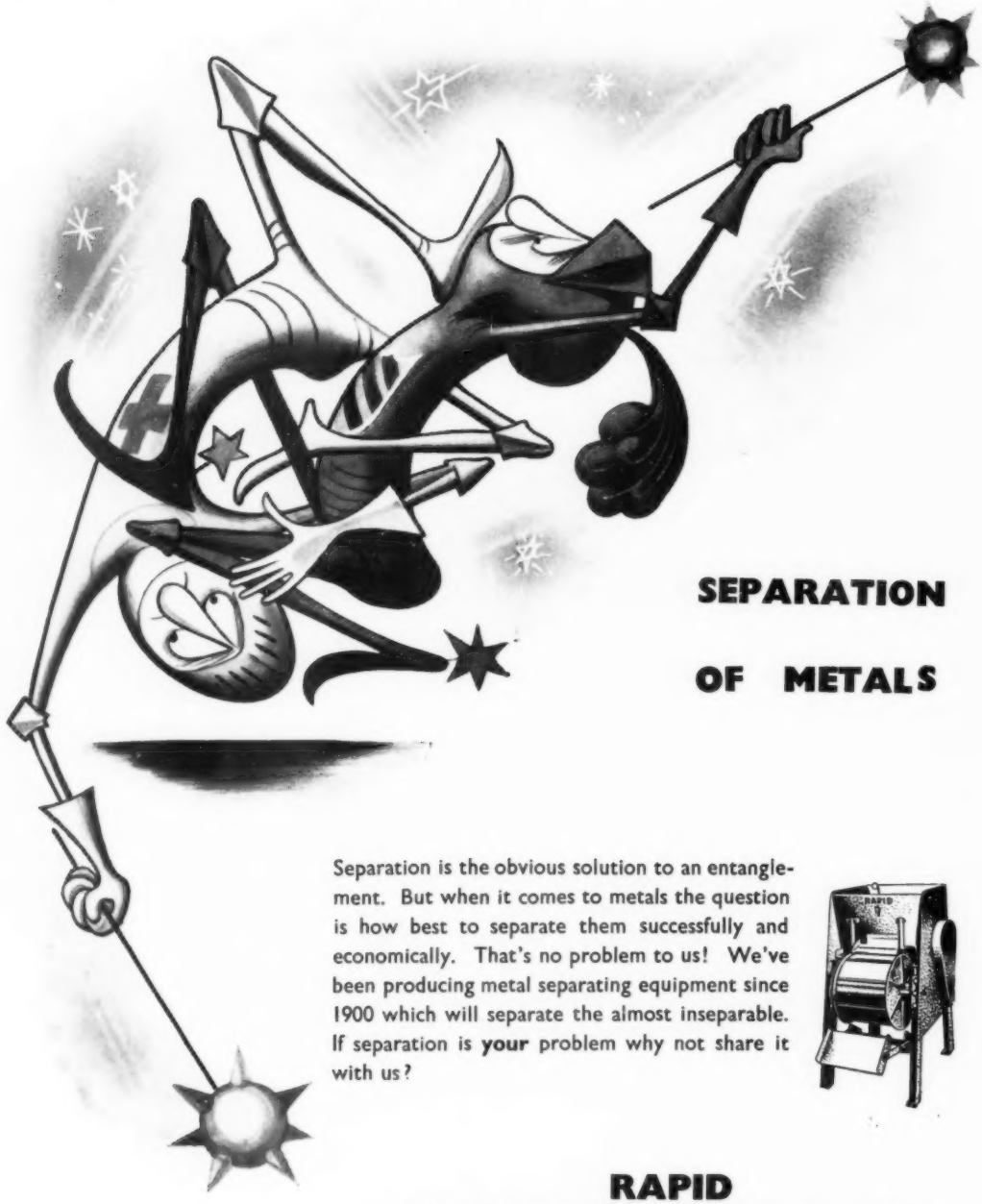

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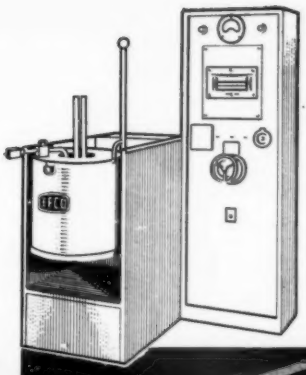

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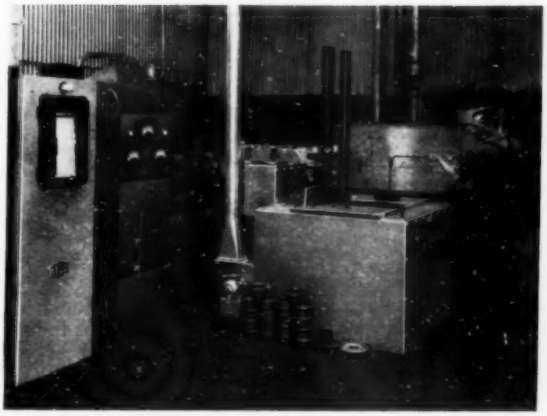
Inexpensive furnace for small charges. Temperature range 590° to 1350°C. Heats up quickly. Entirely self contained.



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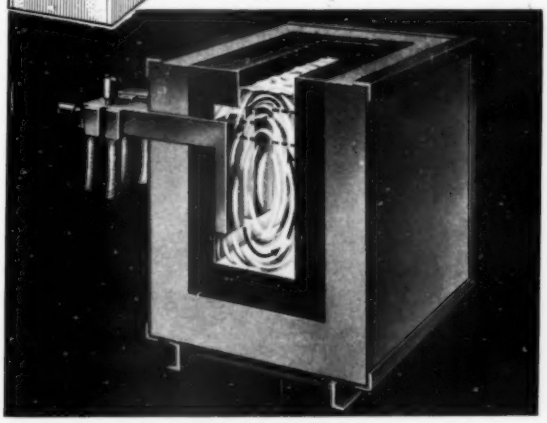

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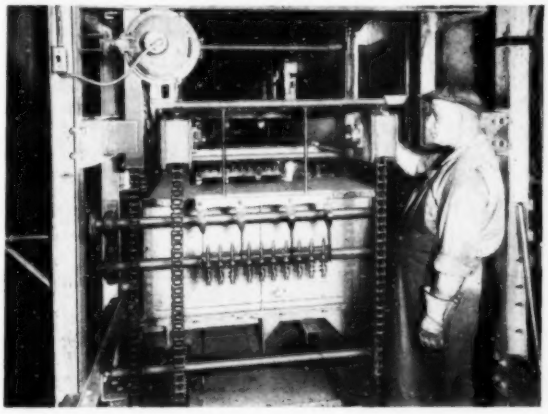
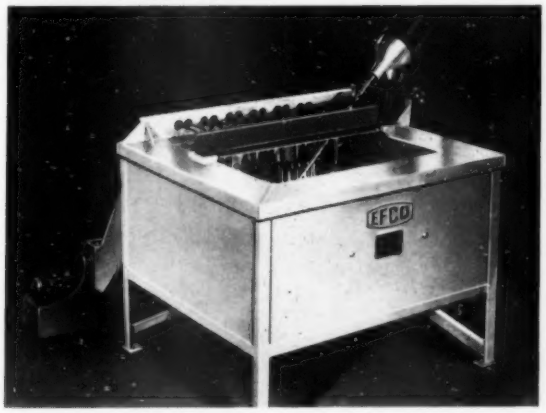


Continuous Isothermal Quench Bath . . . for martempering alloy cast iron cylinder sleeves. Suitable also for austempering and isothermal annealing.



Batch type Isothermal Quench Bath for austempering, martempering, quenching and bright tempering etc. Sizes for all production requirements.

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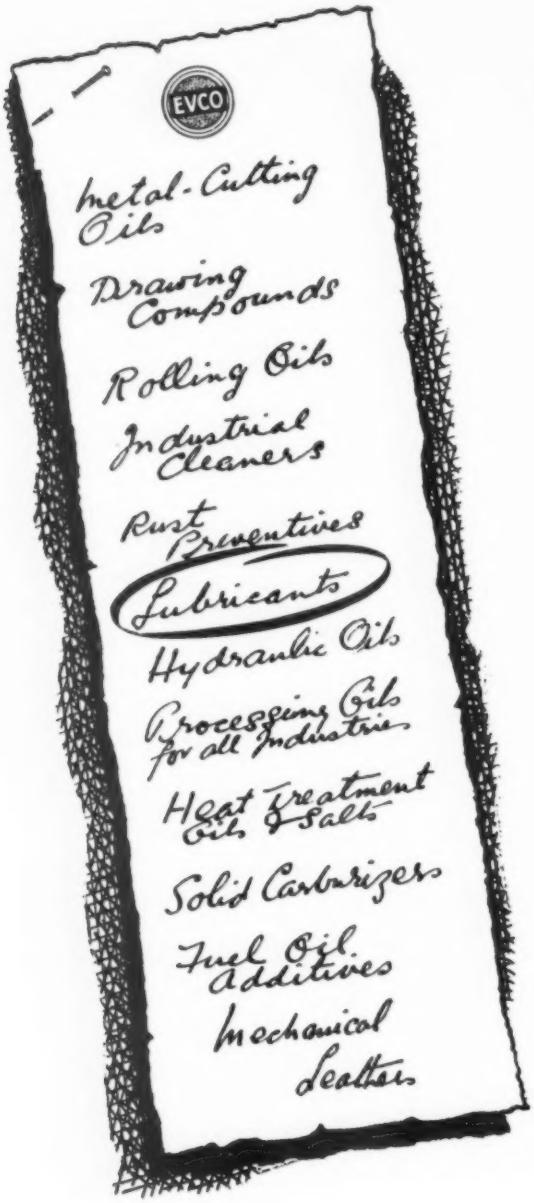

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Our Lubricants are designed to cover the specific requirements of industry and have solved many problems.

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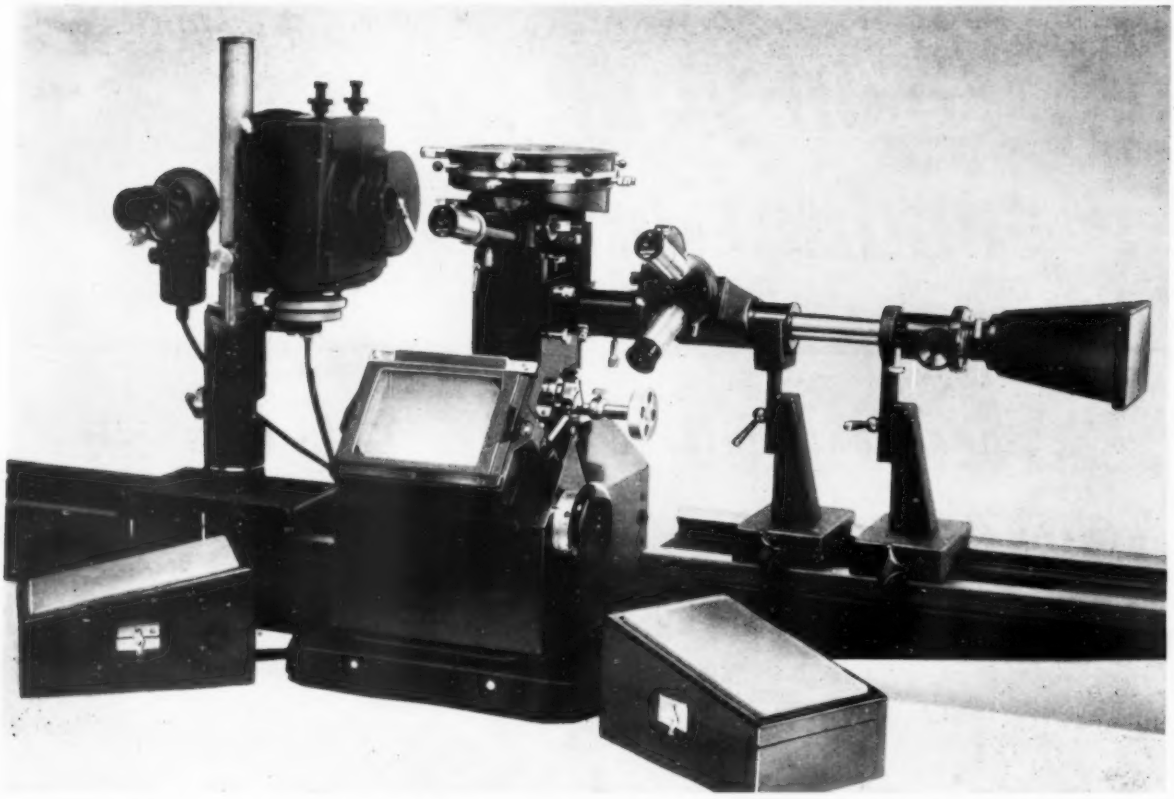

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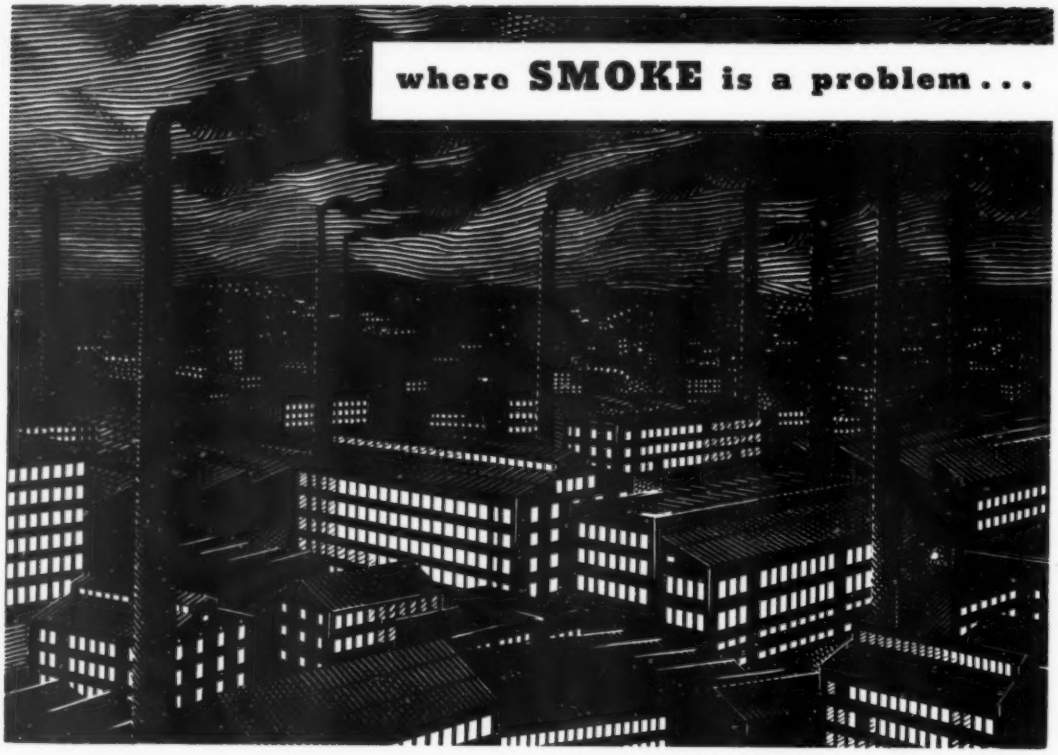

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METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE METALLURGICAL ENGINEER

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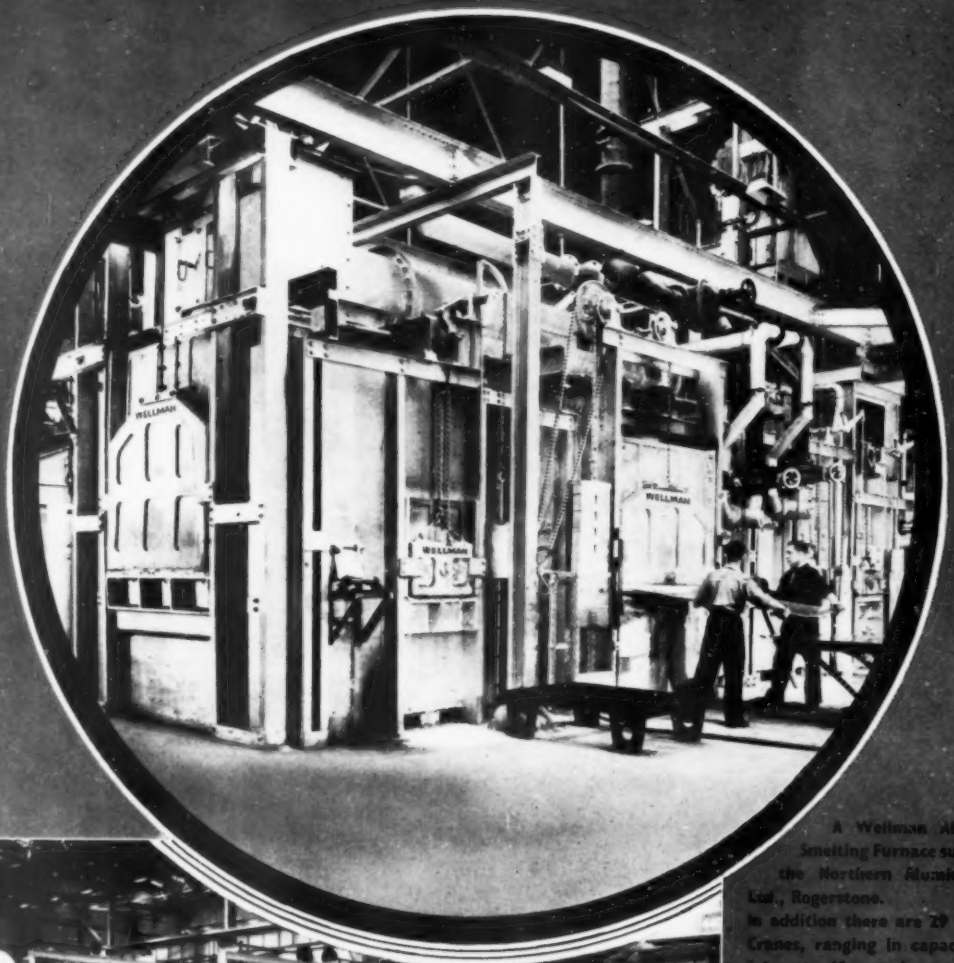
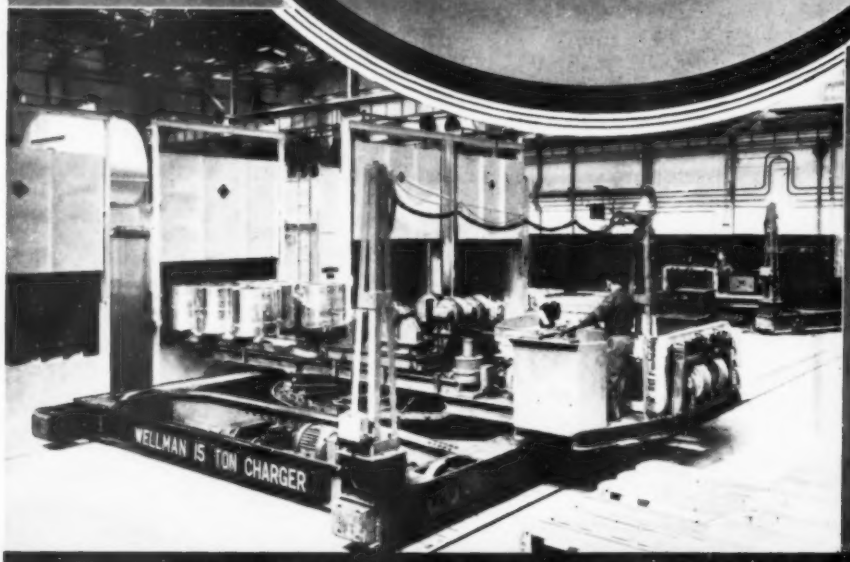
WELLMAN

Furnaces and Mechanical Handling Equipment



A Wellman Aluminium Smelting Furnace supplied to the Northern Aluminium Co. Ltd., Rogerstone.
In addition there are 29 Wellman Cranes, ranging in capacity from 3 tons to 40 tons, in operation at these Works.



Wellman 15 ton Finger Type Chargers and Turntable in service at the British Aluminium Co. Ltd., Falkirk. This installation also includes a 10,000 lbs. Wellman Slab Discharger and a 10,000 lbs. Block Handling Crane.

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METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

MARCH, 1955 Vol. LI. No. 305

Steel Board Report

IN the review of iron and steel production in 1954 and the prospects for 1955, which appeared in our January issue, we concluded by pointing out the difficulties in long-term planning set by the need to assume the likely demand for particular products several years ahead. In particular, the careful consideration necessary in coming to a decision as to whether—and, if so, when—a new wide strip mill should be laid down was emphasised, in view of a cost for the mill and ancillary iron- and steel-making capacity of the order of £100 million. This question remains unanswered in the special report relating to the development of the iron and steel industry over the years 1953 to 1958, which was recently presented to Parliament by the Iron and Steel Board. It is, however, under review by the industry and the Board, as are a number of other long-term problems.

As a result of an examination—in close consultation with representative organisations of the industries affected, and with Government departments—of the likely demand for steels of all types and the possibilities of supply, the Board has concluded that the position should be reviewed on the basis of a demand in 1958 for approximately 22½ million ingot tons of steel. This involves an increase in output from 1953 to 1958 of 4½ million ingot tons as compared with an increase of 2¾ million ingot tons in the previous five years. The 1958 total is made up of 19½ million ingot tons for home consumption (including the manufacture of goods for export) and 3 million ingot tons for steel exported without further fabrication in this country.

In assessing future home demand, the Board have based the figure of 19½ million ingot tons on an assumed upward trend of 4½% per annum between 1953 and 1958, a figure somewhat higher than that for the five years 1948 to 1953 (3·2% per annum). The biggest item in steel consumption is home investment, which in 1953 accounted for almost 10 million ingot tons out of a total home consumption of 15·65 million. Over the five years to 1953, investment increased by 4% per annum, influenced by the stepping up of the housing programme and developments in many basic industries, such as petroleum, chemicals, electricity supply, and the steel industry itself. It is felt that there is likely to be an even greater increase in the next five years as new techniques for increasing industrial efficiency call for more capital equipment per worker, and the road and railway improvement schemes get under way. A figure of 5% per annum appears to the Board to be reasonable in the context of a general policy of increasing the rate of investment in this country.

The second biggest demand is for steel for manufacture into goods for export. Over the five years from 1948 to 1953, the steel taken for this purpose increased at almost the rate of increase now being assumed for steel supplies generally during the period 1953 to 1958. On the whole, it may be more difficult to expand the export of engineering products over the current five years than during the period from 1948 to 1953, owing to the greater severity of competition to be expected from Germany and other countries, and to developments in the metal goods industries in some of the overseas markets. Nevertheless, it is felt that further increases in the volume of metal goods exports should be possible in the context of a growing volume of world trade and the great scope for capital development overseas. It seems likely that certain of the consumer goods industries which use steel will expand more rapidly than at the rate of 5% per annum; in fact the Board suggest that the figures might more nearly approach 10% per annum, but the closeness of approach may depend on the extent to which, and the period for which, hire purchase tax restrictions are imposed.

In the absence of evidence of any substantial long-term increase in the total volume of British steel exports, and the continued expansion of steel-making plants in all parts of the world, the Board feels that it should do no more than assume a small increase to about 3 million ingot tons, compared with a pre-war export of about 2½ million ingot tons and of between 2½ and 3 million ingot tons in more recent years. Further improvements in the efficiency of the home industry should lead to a progressive reduction of imports, although at present sheet and tinplate are being imported in order to enable British mills to maintain their position in foreign markets. It is expected that by 1958 imports will have fallen to not more than about 100,000 tons per annum.

The industry's second development programme is expected to satisfy the requirements envisaged by the Board. The total cost of schemes so far approved is estimated at just over £250 million, and other projects expected to be approved later will probably raise the total of expenditure in the five-year period to £300 million. The resulting 25% increase in total steel output will not be uniformly spread over the various classes, as it is expected that sheet production will increase by 50% and tinplate production by 75%, these increases resulting from increased output from the existing hot strip mills and the commissioning of new finishing plant.

In considering the development plan, the question of raw materials has not been overlooked, and it is expected that steel-making scrap supplies will expand from 9·2 to 10·8 million tons and pig iron from 11·2 to 15·15 million tons. Coking capacity will expand in parallel with the increased blast furnace capacity and discussions with the National Coal Board have indicated that there should be adequate supplies of coking coal available, though some additional blending with lower grade coals will be essential. Home ore requirements are expected to increase to 17½ million tons and imported iron and manganese ore requirements to 17 million tons.

Meeting Diary

12th March

Institute of British Foundrymen (East Midlands Branch). "An Approach to Foundry Mechanical Handling." by C. M. G. WALLWORK. College of Technology and Commerce, Leicester. 6 p.m.

Institute of British Foundrymen (Scottish Branch). Annual Business Meeting and "Technical Control in a Mechanised Bronze Foundry," by W. T. WATT. Royal Technical College, Glasgow. 2.45 p.m. Annual Dinner will be held at the Grosvenor Restaurant after the meeting.

14th March

Institute of Metals (Scottish Local Section). "Post-war Light Alloy Production," by F. KASZ. Followed by the Annual General Meeting. Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2. 6.30 p.m.

Institution of Production Engineers (Sheffield Section). Annual General Meeting. "The Practical Application of Production Engineering Research," by DR. D. F. GALLOWAY. The Grand Hotel, Sheffield. 6.30 p.m.

15th March

Institute of British Foundrymen (Coventry Section). "Foundry Work for Diesel Engine Castings." Film and talk by H. HAYNES. Coventry Technical College, Room A5. 7.30 p.m.

Institute of Fuel (Midland Section). "Selection and Use of Fuels in a Modern Engineering Heat Treatment Department," by H. OXLEY. James Watt Institute, Great Charles Street, Birmingham, 3. 6 p.m.

North East Metallurgical Society. "Some Aspects of the Corrosion Resistance of Low Alloy Steels," by J. F. STANNERS. King's College, Newcastle-upon-Tyne. 7.15 p.m.

Sheffield Metallurgical Association. "Flame Photometry," by G. PADGET. B.I.S.R.A. Laboratories (Sheffield Group), Hoyle Street, Sheffield, 3. 7 p.m.

Institute of Welding (Liverpool Branch). "Welding and Motorcars," by M. H. LUMMUS. Liverpool College of Technology, Byrom Street, Liverpool. 7.15 p.m.

16th March

Institute of Welding (West of Scotland Branch). "Basic Welding Metallurgy," by W. I. PUMPHREY. Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2. 7 p.m.

Society of Instrument Technology (South Yorkshire Section). Annual General Meeting. "Some Instrumentation Problems in the Iron and Steel Industry," by B. O. SMITH, University Buildings, St. George's Square, Sheffield, 1. 7 p.m.

18th March

Society of Chemical Industry Corrosion Group. Joint Meeting with the Liverpool Section. "Control of Corrosion in Boilers," by P. HAMER. Chemistry Lecture Theatre, The University, Liverpool. 7 p.m.

West of Scotland Iron and Steel Institute. "Current Trends and Developments in the Use of Creep-Resisting Steels in Steam Power Plant," by M. G. GEMMILL. 39, Elmbank Crescent Glasgow. 6.45 p.m.

21st March

Institute of Metal Finishing (London Branch). "Electrodeposition of Aluminium," by R. J. HERITAGE. Northampton Polytechnic, St. John Street, London, E.C.1. 6.15 p.m.

Institute of Metals (Sheffield Local Section). "Protection of Steelworks from Atmospheric Corrosion," by DR. F. R. HIMSWORTH. Arranged in association with the Sheffield Society of Engineers and Metallurgists. University Buildings, St. George's Square, Sheffield. 7.30 p.m.

22nd March

Institute of British Foundrymen (Slough Section). Annual General Meeting and "Cylinder Casting," by A. EMMERSON. Lecture Theatre, High Duty Alloys, Ltd., Slough. 7.30 p.m.

Sheffield Metallurgical Association. "Open Hearth Furnaces. (vii) Casting Pit." B.I.S.R.A. Laboratories (Sheffield Group), Hoyle Street, Sheffield, 3. 7 p.m.

23rd March

Institute of British Foundrymen (Birmingham Branch). Works Visit to Sterling Metals, Ltd., Nuneaton. 2.30 p.m. "Running and Feeding Metals for Light Alloys," by W. J. SULLY. Sterling Metals, Nuneaton. 7.15 p.m.

Society of Instrument Technology (Chester Section.) "High Vacuum Technique." W. EDWARDS & CO. (LONDON) LTD. Board Room of the Chester and District Hospital Committee, 5, Kings Buildings, King Street, Chester. 7 p.m.

24th March

Institute of British Foundrymen (Northampton and District Section). "Pattern Making for Production Moulding," by S. A. HORTON. Plough Hotel, Northampton. 7.30 p.m.

Institute of Metals (Birmingham Local Section)., "Shielded Arc Welding," by DR. E. C. MOORE. James Watt Memorial Institute, Great Charles Street, Birmingham. 6.30 p.m.

Institute of Welding (North London Branch). "Recent Achievements in Welding Research," by H. G. TAYLOR. Polytechnic, Regent Street, London, W.1. 7.30 p.m.

25th March

Institute of Welding (Birmingham Branch). "Principles of Nozzle Design," by R. E. JAHN. Birmingham and Midland Institute, Paradise Street, Birmingham, 1. 7.30 p.m.

Manchester Association of Engineers. Annual General Meeting and "Engineering Problems Associated with Production and Operations at Low Temperature," by H. E. CHARLTON. Engineers Club, Albert Square, Manchester, 2. 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders. "The Geometrical Size Effect in Notch Brittle Fracture," by DR. A. A. WELLS. Mining Institute, Newcastle upon Tyne. 6.15 p.m.

28th March

Institute of British Foundrymen (Sheffield Branch). "Foundry Safety: Some Effects of Changing Legislation," by R. F. OTTIGNON. College of Technology, Pond Street, Sheffield. 7.15 p.m.

29th March

Institute of Metals (Oxford Local Section). Annual General Meeting, followed by Discussion on Non-Destructive Testing, introduced by DR. E. G. STANFORD. Ballroom of the Cadena Cafe, Cornmarket Street, Oxford. 7 p.m.

Sheffield Metallurgical Association. "The Mechanism of the Action of Boron in Low Alloy Steels," by F. B. PICKERING. B.I.S.R.A. Laboratories (Sheffield Group), Hoyle Street, Sheffield, 3. 7 p.m.

29th March–1st April

Institute of Metals. Spring Meeting including Annual May Lecture, Annual General Meeting and Symposium on "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys. III—The Control of Quality in Heat-Treatment and Final Operations."

30th March

Institute of British Foundrymen (London Branch). "Safety in the Foundry," by A. TALBOT. Waldorf Hotel, London, W.C.1. 7.30 p.m.

Institute of British Foundrymen (West Riding of Yorkshire Branch). "Sand for Floor Moulding," by W. B. PARKES. Technical College, Bradford. 6.30 p.m.

Society of Chemical Industry Corrosion Group. Spring Lecture: "Attention to Corrosion in U.S.A.," by F. L. LAQUE, Chemical Society, Burlington House, Piccadilly, London, W.1. 6.30 p.m.

31st March

Institute of Welding (South Wales Branch). "Welding and Riveting in Steel Construction," by F. KOENIGSBERGER. Stothert and Pitt, Ltd., Bristol Road, Bath.

Liverpool Metallurgical Society, Conversazione. Liverpool Engineering Society, 9 The Temple, Dale Street, Liverpool.7 p.m.

31st March and 1st April

Society of Chemical Industry Corrosion Group. Symposium on the Protection of Structural Steel. (Further details may be found on p. 290 of the December 1954 issue of METALLURGIA.) Institution of Civil Engineers, Great George Street, London, S.W.1. 9.30 a.m., and 2.30 p.m.

Continued on page 120

Some Effects of Variation in the Zinc Content on the Mechanical Properties and Corrosion Resistance of Al-Si-Cu Alloys*

Comments from the British Non-Ferrous Metals Research Association.

A PROGRAMME of tests has been undertaken to ascertain the extent to which the zinc content of LM-4 type alloy might be raised without unduly adverse effects on the properties of the material. If the zinc content could be raised substantially without such adverse effects, particularly on the ductility and corrosion resistance of the material, a wider range of secondary materials would be available for the manufacture of the alloy.

It is known that the ductility of this type of alloy, particularly of materials which have been aged at room and elevated temperatures, is markedly dependent on the magnesium content, which is restricted in the existing specification to not more than 0·15%. In practice the magnesium content is normally considerably lower than this, in the range 0·05—0·1%, but since the co-presence of zinc might influence in one direction or another the known marked effects of magnesium, the programme of tests described was designed to study the effects of both variables. Accordingly a batch of commercial LM-4 alloy with typical contents of copper, silicon and the normally occurring impurities iron, manganese, etc., was obtained, and sand castings were made from melts the magnesium and zinc contents of which were adjusted by additions of the metals. Tensile and torsion tests were carried out on the as-cast and artificially aged alloys and the results of these tests are given. Other tests were made to examine the properties of the materials after ageing at room temperature and exposure to atmospheric corrosion for periods up to 12 months.

Experimental

Materials

The alloys were made by adding zinc and magnesium (99·96% purity) to LM-4 ingot supplied by a member firm. The ingot material was all taken from the same batch and had the following analysis:

Cu%	Mg%	Si%	Fe%	Mn%
2·35	0·01	5·32	0·66	0·40
Ni%	**Zn%**	**Pb%**	**Sn%**	**Ti%**
0·12	0·46	0·05	0·03	0·02

Melting and Casting

The 45 lb. melts were prepared in the following way. The ingot was melted down, covered with Foseco Coveral 36A flux, and any additional zinc and magnesium required were added as the metals. The melt was then degassed at about 740° C. by flushing with "White Spot" nitrogen for 10 minutes. Freedom from dissolved gas was checked with the B.N.F. Reduced Pressure Gas Tester. Pouring was started when the temperature had fallen to 720° C.

Sixty torsion test specimens and 8 D.T.D. type test-bars were cast from each melt. The torsion test specimens were cast twelve at a time using the pattern illustrated in Fig. 1. All the moulds were made from Mansfield sand.

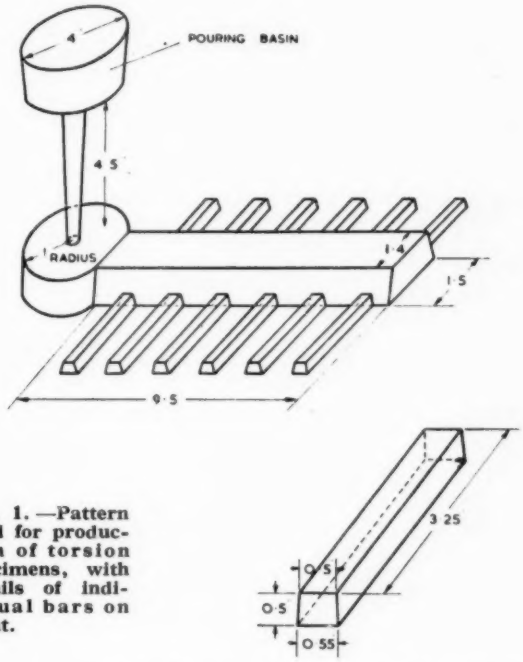

Fig. 1.—Pattern used for production of torsion specimens, with details of individual bars on right.

Analysis

Result of analyses for zinc and magnesium contents are given in Table 1.

Mechanical Tests

Tensile tests were made on 0·564 in. diameter tensile specimens, with screwed ends, machined from D.T.D. bars, axial loading shackles being used. Elongations on $4\sqrt{A}$ were measured by fine pointed dividers to an accuracy of 0·25% of the gauge length, after clamping the fracture faces together in a suitable jig (Fig. 2).

The torsion tests were made on specimens having a diameter of 0·300 in. on the reduced section, which had

TABLE I—ANALYSES OF CASTS

B.N.F. Mark	Nominal Composition		Actual Composition	
	Magnesium %	Zinc %	Magnesium %	Zinc %
QQL ..	0·05	0·5	0·04	0·44
QQM ..	0·05	1·0	0·04	0·97
QQN ..	0·05	1·5	0·03	1·44
QQO ..	0·05	3·0	0·04	3·40
QQP ..	0·15	0·5	0·14	0·52
QQR ..	0·15	1·0	0·13	0·91
QQS ..	0·15	1·5	0·13	1·49
QQJ ..	0·15	3·0	0·14	3·07
QQU ..	0·25	3·0	0·25	3·03

* B.N.F.M.R.A. Report R.R.A. 1042P. The work described in this paper was made available to members of the British Non-Ferrous Metals Research Association in two confidential research reports issued in May and September, 1954.

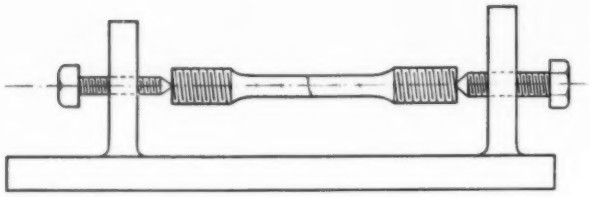

Fig. 2—Jig for elongation measurements

a length of 1 in., with $\frac{5}{8}$ in. radius fillets. Angle of twist was measured to the nearest degree (Fig. 3).

The angle of twist which the specimen will withstand before fracture in the torsion tests correlates reasonably well with the ductility measured in a tensile test. The angle of twist, however, can be measured with more precision than the elongation on 2 in. in a tensile test, and it was for this reason that the torsion test was used in the belief that it would detect with greater certainty any adverse effects of unduly high magnesium or zinc contents on the ductility of the materials.

Artificial Ageing

Six torsion test specimens and three D.T.D. bars from each cast were aged at 165° C. for 16 hours before testing. The torsion specimens were taken as far as possible from different castings.

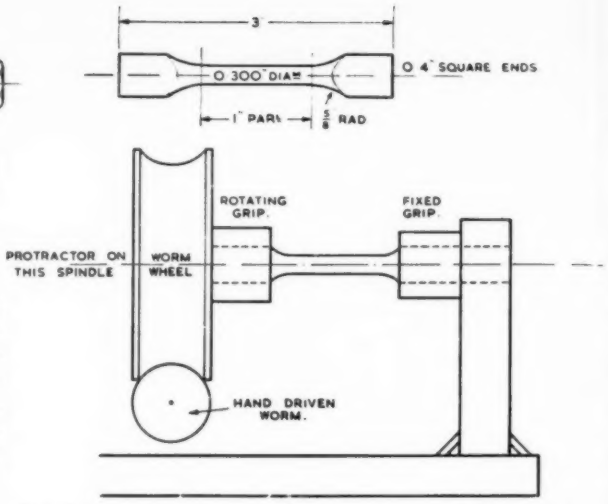

Fig. 3.—Torsion tester with specimen details above.

Natural Ageing and Exposure Tests

(*a*) *Outdoor Exposure*

Each specimen was gripped at one end between the two halves of a porcelain insulator bolted to a metal rack placed on the roof of the laboratories at 81-91 Euston Street, London, N.W.1. The specimens were facing south west and were mounted so that the axis of each specimen was at 30° to the horizontal and about 1 ft. above roof level.

(*b*) *High Humidity Exposure*

The specimens were suspended vertically by nylon cords from aluminium alloy rods hung in a constant

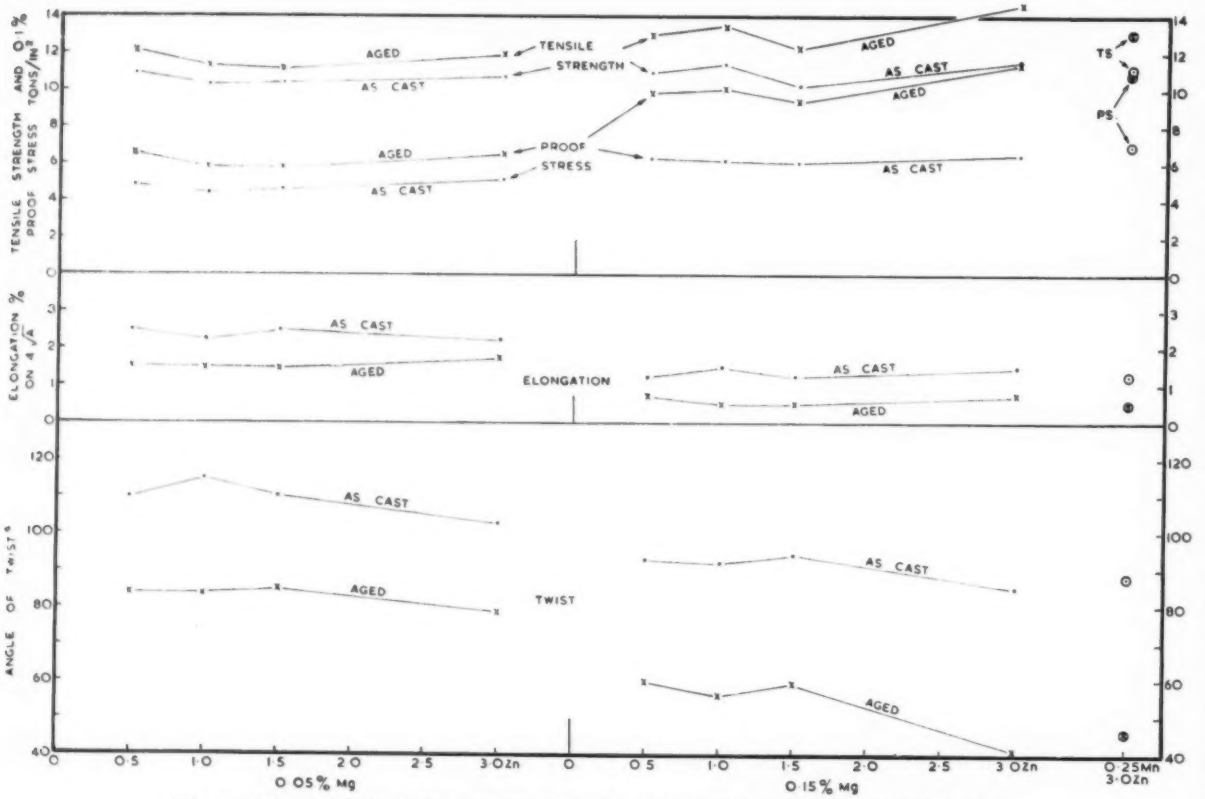

Fig. 4.—Effect of zinc and magnesium content on mechanical properties of LM-4 alloy

TABLE II.—DETAILED RESULTS OF MECHANICAL TESTS.

Alloy	Mg% / Zn%	0·05 / 0·5	0·05 / 1·0	0·05 / 1·5	0·05 / 3·0	0·15 / 0·5	0·15 / 1·0	0·15 / 1·5	0·15 / 3·0	0·25 / 3·0
B.N.F. Mark		QQL	QQM	QQN	QQO	QQP	QQR	QQS	QQJ	QQU
1 Week after Casting.	Angle of Twist°	104, 129, 112, 123, 94, 96 — Av. 110	123, 121, 110, 122, 112 — Av. 117½	111, 107, 122, 106, 110, 103 — Av. 110	95, 118, 106, 100, 98 — Av. 103	107, 105, 86, 84, 86, 91 — Av. 93	78, 100, 111, 92, 81, 89 — Av. 92	101, 75, 79, 102, 111, 110 — Av. 94½	80, 70, 83, 98, 85, 97 — Av. 85½	92, 99, 94, 80, 76, 86 — Av. 88
	0·1% Proof Stress tons/sq. in.	4·7, 4·8, 4·8 — Av. 4·8	4·4, 4·5, 4·3 — Av. 4·4	4·6, 4·6, 4·6 — Av. 4·6	5·1, 5·1, 5·1 — Av. 5·1	6·4, 6·2, 6·3 — Av. 6·3	6·1, 6·3, 6·0 — Av. 6·0	6·1, 5·9, 6·1 — Av. 6·1	6·3, 6·5, 6·3 — Av. 6·4	6·7, 7·0, 7·0 — Av. 6·9
	Tensile Strength tons/sq. in.	11·0, 10·7, 11·0 — Av. 10·9	10·2, 10·3, 10·3 — Av. 10·3	10·3, 10·2, 10·6 — Av. 10·4	10·6, 10·8, 10·8 — Av. 10·7	11·0, 10·9, 10·8 — Av. 10·9	11·2, 11·4, 11·3 — Av. 11·3	10·3, 10·2, 10·1 — Av. 10·2	11·3, 11·8, 11·5 — Av. 11·5	11·0, 10·9, 11·4 — Av. 11·1
	Elongation on $4\sqrt{A}$ %	2½, 2½, 2½ — Av. 2½	2, 2½, 2½ — Av. 2¼	2½, 2½, 2½ — Av. 2½	2, 2½, 2¼ — Av. 2¼	1, 1½, 1 — Av. 1¼	1½, 1½, 1½ — Av. 1½	1, 1¼, 1¼ — Av. 1¼	1½, 1½, 1½ — Av. 1½	1½, 1¼, 1¼ — Av. 1¼
Aged 16 hr. at 165° C.	Angle of Twist°	88, 92, 75, 82 — Av. 84	84, 85, 64, 88, 94, 88 — Av. 84	94, 81, 77, 88, 89, 81 — Av. 85	71, 85, 82, 89, 80, 69 — Av. 79	64, 63, 57, 63, 62, 50 — Av. 60	62, 59, 55, 54, 59, 49 — Av. 56½	45, 67, 52, 60, 75, 57 — Av. 59½	46, 35, 45, 44, 38, 45 — Av. 42	51, 51, 46, 41, 36, 48 — Av. 46
	0·1% Proof Stress tons/sq. in.	6·5, 6·8, 6·6 — Av. 6·6	5·7, 5·8, 5·8 — Av. 5·8	5·8, 5·8, 5·9 — Av. 5·8	6·6, 6·3, 6·5 — Av. 6·5	9·8, 9·8, 9·8 — Av. 9·8	9·9, 10·4, 9·8 — Av. 10·0	9·6, 9·2, 9·7 — Av. 9·5	11·5, 11·5, 11·3 — Av. 11·4	—, 11·0, 10·7 — Av. 10·8
	Tensile Strength tons/sq. in.	11·8, 12·2, 12·2 — Av. 12·1	11·5, 11·3, 11·1 — Av. 11·3	11·4, 10·9, 11·1 — Av. 11·1	11·8, 11·9, 11·7 — Av. 11·8	13·0, 12·7, 13·0 — Av. 12·9	13·5, 14·1, 13·6 — Av. 13·7	12·4, 11·8, 12·4 — Av. 12·2	14·5, 14·4, 14·8 — Av. 14·6	12·8, 13·1, 13·0 — Av. 13·0
	Elongation on $4\sqrt{A}$ %	1½, 1½, 1½ — Av. 1½	1½, 1½, 1½ — Av. 1½	1¾, 1½, 1½ — Av. 1½	1¾, 1¾, 1¾ — Av. 1¾	1, ¾, ¾ — Av. ¾	½, ½, ½ — Av. ½	½, ½, ¾ — Av. ½	¾, ½, ¾ — Av. ¾	½, ½, ½ — Av. ½
Angle of Twist° after 3 Months Exposure										
Outdoor		94, 105, 101, 101, 91 — Av. 98½	101, 101, 97, 96 — Av. 99	97, 92, 91, 93, 100 — Av. 94½	90, 89, 94, 95, 94 — Av. 92½	93, 82, 76, 81, 78 — Av. 82	78, 72, 88, 65, 77 — Av. 76	85, 92, 90, 70, 93 — Av. 86	70, 56, 75, 81, 74 — Av. 71	76, 72, 74, 71, 71 — Av. 73
In Humidity Chamber		78, 109, 100, 92, 89 — Av. 93½	85, 89, 100, 102, 89 — Av. 95	97, 98, 106, 106, 89 — Av. 99	97, 93, 105, 104 — Av. 100	92, 87, 92, 93, 90 — Av. 91	70, 93, 62, 81, 75 — Av. 76	90, 76, 83, 114, 80 — Av. 88½	66, 70, 74, 83, 75 — Av. 73½	74, 74, 82, 86, 70 — Av. 77
In Non-Corrosive Atmosphere		86, 75, 88, 84, 86 — Av. 84	92, 112, 91, 107, 107 — Av. 102	83, 116, 84, 115, 89 — Av. 97½	105, 83, 110, 90, 83 — Av. 94	80, 94, 97, 101, 89 — Av. 92	76, 81, 92, 69, 91 — Av. 82	101, 96, 94, 87, 100 — Av. 95½	68, 70, 72, 63, 86 — Av. 72	97, 73, 76, 100, 84 — Av. 86
Angle of Twist° after 6 Months Exposure										
Outdoor		77, 89, 93, 84, 105 — Av. 89½	86, 86, 99, 82, 86 — Av. 88	94, 81, 81, 91, 75 — Av. 84½	78, 81, 75, 92 — Av. 81½	84, 87, 97, 82, 62 — Av. 82½	60, 71, 83, 65, 86 — Av. 73	74, 65, 79, 75, 76 — Av. 74	54, 66, 58, 64, 66 — Av. 61½	66, 80, 70, 73, 58 — Av. 69½
In Humidity Chamber		82, 93, 79, 101, 95 — Av. 90	99, 77, 107, 97, 86 — Av. 93	104, 93, 90, 93, 93 — Av. 94½	100, 91, 87, 90, 90 — Av. 91½	93, 80, 84, 76, 78 — Av. 82	79, 79, 53, 67, 91 — Av. 74	80, 98, 82, 94, 80 — Av. 87	65, 61, 75, 69, 68 — Av. 67½	82, 81, 67, 71, 71 — Av. 74½
In Non-Corrosive Atmosphere		74, 91, 105, 79, 95 — Av. 89	83, 99, 100, 99, 100 — Av. 96	90, 84, 93, 83, 90 — Av. 88	77, 101, 91, 90, 102 — Av. 92	97, 78, 86, 88, 66 — Av. 83	74, 55, 83, 72, 98 — Av. 76½	89, 80, 110, 77, 93 — Av. 90	71, 74, 54, 75, 80 — Av. 71	68, 83, 84, 65, 68 — Av. 73½
Angle of Twist° after 12 Months Exposure										
Outdoor		70, 86, 74½, 87, 87 — Av. 81	86, 87½, 95, 80, 92 — Av. 85	95, 92, 79, 67, 74½ — Av. 81½	93½, 89½, 56½, 87, 64 — Av. 78	75, 86, 68, 73, 90½ — Av. 78½	52, 68, 60½, 70½, 69 — Av. 64	98½, 89, 60, 90, 78 — Av. 83	68, 79, 55, 66, 81 — Av. 70	62, 70, 69½, 61, 66½ — Av. 65½
In Humidity Chamber		99, 84, 84, 90, 106 — Av. 89	86, 108, 94½, 84½, 94 — Av. 93	98, 102, 94, 101, 98 — Av. 99	86, 101½, 81, 90½, 98 — Av. 89	81, 103, 72, 84½, 77½ — Av. 84	82½, 70, 79, 76, 76 — Av. 77	69, 79, 94½, 83, 91½ — Av. 83	70, 67, 74, 65, 74½ — Av. 70	80, 56, 70, 65, 54 — Av. 65
In Non-Corrosive Atmosphere		81½, 87½, 95, 92, 100 — Av. 91	102, 95, 94, 95, 84 — Av. 94	102, 99, 100, 94, 102 — Av. 99½	95, 106, 82½, 78, 86 — Av. 89½	59, 76½, 91½, 76½, 61½ — Av. 73	73, 88, 71½, 92, 88 — Av. 82½	73, 76, 83, 75, 81 — Av. 78	62, 71½, 78, 61½, 64½ — Av. 67½	81, 75, 72½, 89½, 65 — Av. 76½

humidity constant-temperature room in which relative humidity was 80% at 20° C.

(c) *Non-Corrosive Exposure*

The specimens, spaced out on layers of filter paper, were stored in a calcium chloride desiccator in a constant temperature room at 20° C.

Results and Discussion

Tests on Materials 1 *Week after Casting and after Artificial Ageing Treatment*

The results of these tests are detailed in Table II and the average values are plotted in Fig. 4.

The average values of twist in the torsion tests are plotted in Fig. 5 against the average values of elongation

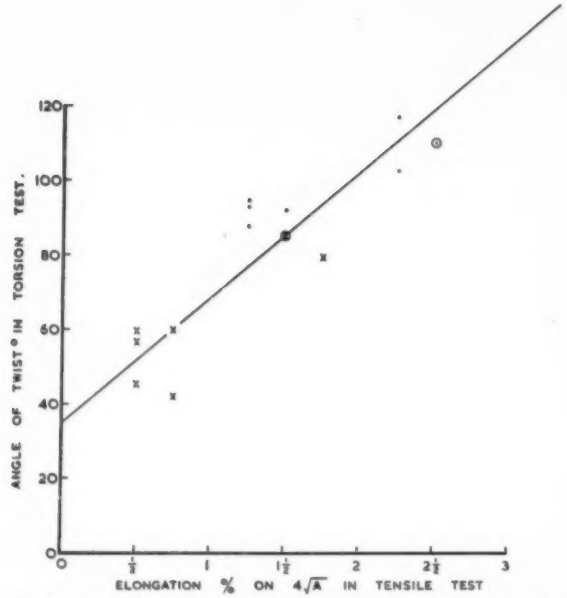

Fig. 5.—Relationship between angle of twist and elongation

in the tensile tests. The total deformation, elastic plus plastic, is measured in the torsion test, whereas in the tensile test the elongation measurement after fracture gives only the plastic deformation. The average straight line in Fig. 5. shows that at zero elongation in the tensile test there would be 30-40° twist in the torsion test. It would appear, therefore, that when the specimen shown in Fig. 3 is used, the average elastic twist in all the materials is of the order of 30-40° and that a plastic elongation of 1% in the tensile test corresponds to a plastic twist of about 30° in the torsion test.

Inspection of Table II and of Fig. 4 shows that the strength and ductility of the as-cast material is very little affected by zinc contents in the range examined, 0·5—3·0%. The same is true of the artificially aged alloys containing 0·05% magnesium, but the torsion tests suggest some slight decrease in ductility when the zinc content exceeds about 1·5% in the material containing 0·15% magnesium.

Tests after Natural Ageing and after Exposure to the Atmosphere or to High Humidity

In these experiments torsion tests were used to determine whether natural ageing or corrosion damage had caused any decrease in ductility. The results are detailed in Table II and the averages are plotted in Fig. 6, which also includes for comparison the results obtained after ageing 16 hours at 165° C. Visual examination of the specimens after exposure showed no difference between the whole range of alloys.

Some ageing of all the alloys has clearly occurred during the 3, 6 or 12 months' exposure time, but in no case has the ductility, as measured by angle of twist,

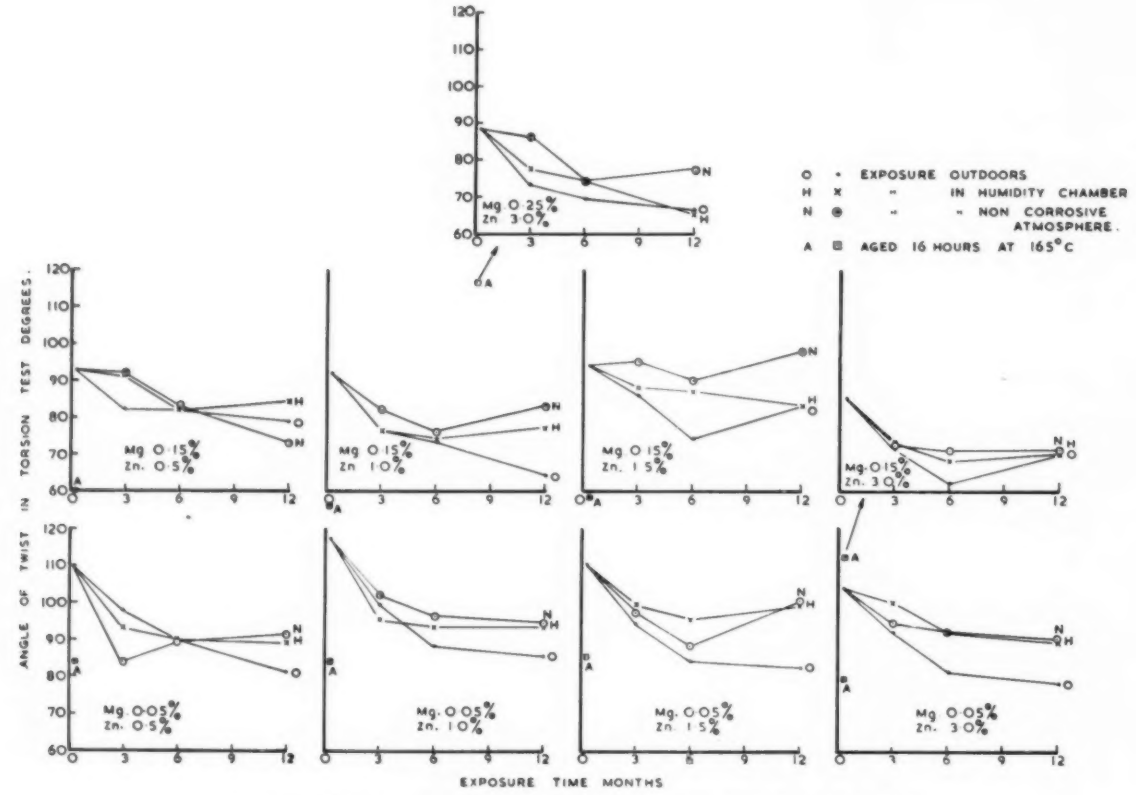
O • EXPOSURE OUTDOORS
H X " IN HUMIDITY CHAMBER
N ⊕ " " NON CORROSIVE ATMOSPHERE.
A ⊡ AGED 16 HOURS AT 165°C
ANGLE OF TWIST IN TORSION TEST DEGREES.
Mg. 0·25% Zn. 3·0%
Mg. 0·15% Zn. 0·5%
Mg. 0·15% Zn. 1·0%
Mg. 0·15% Zn. 1·5%
Mg. 0·15% Zn. 3·0%
Mg. 0·05% Zn. 0·5%
Mg. 0·05% Zn. 1·0%
Mg. 0·05% Zn. 1·5%
Mg. 0·05% Zn. 3·0%
EXPOSURE TIME MONTHS

Fig. 6.—Effect of exposure conditions on average torsion test results.

dropped below the value given by the artificially aged condition.

There is no evidence from the test results that increase in the zinc content results in appreciable lowering of the ductility in any of the three exposure conditions.

The difference in ductility between the groups of alloys containing 0·15% magnesium and 0·05% magnesium was not so well marked after natural ageing as was the case after the artificial ageing treatment, and it seems probable that after prolonged ageing at room temperature the ductilities of the two groups of alloys will be very similar.

GENERAL CONCLUSION

Additions of zinc up to 2% have no adverse effect on the tensile strength, proof stress, or ductility of the LM-4 type alloy containing either 0·04 or 0·14% magnesium in the as-cast or artificially aged conditions. Neither do they have any adverse effect on naturally aged materials exposed for 12 months outdoors or in a high humidity room. Insofar, therefore, as this evidence is relevant to the important service properties of the material, it shows that additions of zinc up to about 2% do not adversely affect the alloy.

Reactivity of Freshly Formed Metal Surfaces

Although of a fundamental character, it is expected that studies of the nature of freshly abraded surfaces now being undertaken in the Lubrication and Wear Division of the Mechanical Engineering Research Laboratory will lead to a better understanding of lubrication problems and of the operating mechanism of cutting fluids.

EXPERIMENTS carried out by the Lubrication and Wear Division of the Mechanical Engineering Research Laboratory have shown that when metals are cut under water, or are allowed to oxidise in moist air, appreciable quantities of hydrogen peroxide are formed on the surface.

This work stems from a discovery first noted in 1950 by J. Kramer, a German worker, at the Physikalisch-Technische Bundesanstall, Brunswick. Kramer drew attention to the fact that worked surfaces emit particles capable of actuating an open-ended Geiger counter operated in air. He assumed that the particles were electrons and that their emission was due to phase changes occurring on the freshly disturbed metal surface. Various explanations have been put forward for this phenomenon. Kramer himself postulated the existence of a particular state of metals which he described as ' non-metallic ', but experiments by other workers indicated that adsorption might play an important part in inducing emission.

The Kramer effect offers the possibility of using techniques similar to those employed in work with radioactive tracers for investigating physical and chemical phenomena occurring on freshly exposed metal surfaces. Although no radioactivity actually occurs, counts can be made by means of an open-ended Geiger counter tube and a grid, the latter being biased so as to direct charged particles such as electrons from the freshly disturbed metal surfaces into the counter.

Newly abraded surfaces also resemble radioactive materials in their ability to form images on photographic plates, this property being due to chemical reactions near or at the surface of the deformed metal. This phenomenon was discovered in 1897 by W. J. Russell, who was able to show that the image produced on a photographic plate was caused by a gas, and that extremely small quantities of hydrogen peroxide vapour acted in a similar manner to the gas produced on freshly abraded metal surfaces[2]. A satisfactory explanation of the Russell effect is obtained if the Kramer effect is assumed to be the primary cause of the reaction.

A third type of reaction was discovered by Shaw in 1948 during an investigation of the action of fluids used for lubrication in metal cutting[3]. It was observed that certain organic compounds reacted vigorously with the metal cut, while relatively inert to the metal in bulk. Certain reactions, which normally require anhydrous conditions, proceeded vigorously even in the presence of water. Shaw termed this phenomenon "mechanical activation" and ascribed the high reaction rates he noted to the high temperatures and pressures at the tool face during cutting, together with the great reactivity of the highly stressed nascent surface produced. It seemed probable that this phenomenon was also a manifestation of the Kramer effect.

Believing that study of these phenomena might result in a better understanding of the fundamental nature of the wearing process, the Lubrication and Wear Division of the Mechanical Engineering Research Laboratory embarked upon a comprehensive investigation of the properties of freshly worked metal surfaces. One of the initial aims was to link the Kramer effect with the Russell effect and with Shaw's "mechanical activation".

Experimental Study

In a series of preliminary experiments, photographic plates were exposed to the action of abraded zinc and aluminium specimens. Images were produced on the plates ; further investigations showed, however, that these were not directly caused by electrons, but were due to traces of hydrogen peroxide formed in the presence of oxygen and moisture. It was also found that freshly-evaporated metal films behave in a similar manner to abraded surfaces.

Two experimental methods were thus available for the examination of worked metal surfaces. One was a physical technique based on the Kramer effect and involving the use of an open-ended Geiger counter, the other a chemical method using the presence of hydrogen peroxide (Russell effect).

In the course of the investigation the observations of previous workers were confirmed and further discoveries were made. A series of experiments was carried out in a converted coating unit using a Geiger-Muller counter. Since the "quality" of the pulses seemed to be of interest, a cathode-ray oscillograph was used as the observing and recording unit. Specimens of various metals were abraded and placed under the counter, which was then brought to operating conditions.

Aluminium and zinc were found to give by far the greatest number of pulses. Very soft metals, like lead and indium, and hard metals like chromium gave fewer pulses, while nickel, copper and brass occupied an intermediate position.[4]

Experiments with a charged grid between the specimen and the counter anode showed that the particles actuating the counter were negatively charged. In further experiments an alternating voltage was placed on the grid and the mobility of the charged particles was measured, using the counter as a current-measuring device. It was found that the particles actuating the counter were not electrons, as assumed by Kramer, but oxygen molecules which had picked up electrons at or near the abraded surface.

Effect of Light

One of the most interesting discoveries made by the Division was the effect of light on the emission from an abraded surface. This effect differs from ordinary photo-emission, in that emission from abraded surfaces occurs at lower energies (longer wave-lengths) than from undisturbed or aged surfaces. Experiments with freshly cleaved single crystals of zinc have been described[5]. One of the cleaved surfaces was abraded, whereas the other was left undisturbed. Both surfaces were examined by means of an open-ended Geiger-Muller counter, the aim being to determine their response to daylight through glass (with most of the ultra-violet wave-lengths cut off). Great care was taken to ensure absolutely uniformity of the geometrical and illumination conditions in both experiments. Stray fields were eliminated by a zinc grid interposed between the counter and specimen and operated at a positive potential.

Under these conditions, the cleaved surface gave 40 counts/min., whereas the cleaved and abraded surface gave 275 counts/min. The cut-off wave-length for the photo-electric response of zinc lies normally well in the ultra-violet at about 3,000 Å. The fact that it had been shifted into the visible spectrum, to about 5,000 Å, indicates that the abrasion process produces, on the surface, areas having a lower work function than is usually ascribed to the particular metal under examination.

The behaviour of these surfaces was further checked by means of the Russell effect. Another single crystal of zinc was prepared in the manner previously described. Both the cleaved and the cleaved and abraded surfaces were exposed to a photographic plate for 20 hours. After development, the cleaved and abraded surface gave a very dark image, but the cleaved surface gave scarcely any image.

Cutting Experiments

Further experiments were undertaken in order to establish whether the Russell effect could be produced by cutting metals in the presence of water and oxygen. This work has been described by Grunberg[6]. A metal block approximately 4½ in. × 3 in. × 2 in. was firmly attached to the bottom of a plastic trough. The trough was clamped into the machine vice of a hydraulic shaping machine and filled with 1000 ml. distilled water, the metal block being completely immersed. A high speed steel tool was introduced and orthogonal cuts were taken with a feed of 0·002 in. In order to keep the temperature as low as possible low cutting speeds of about 4 ft. min were used except when cutting nickel when the cutting speed was about 5·5 ft./min. The cutting chips were kept submerged but were occasionally rearranged in the trough to prevent accumulation and exposure to air. During the experiment the temperature of the water was measured and after the required number of cuts, the water was immediately syphoned off and aliquot portions were analysed for hydrogen peroxide.

These experiments showed that when fresh metallic surfaces are produced under water, by cutting zinc, aluminium, magnesium and nickel, measurable quantities of hydrogen peroxide are formed. With copper, however only very small quantities of hydrogen peroxide can occasionally be detected. This agrees with evidence obtained from chemical examination of freshly abraded surfaces, when it was found that abraded copper and brass failed to blacken photographic plates.

The investigators conclude that phenomena similar to the Russell effect can be produced by a process of "mechanical activation". The formation of hydrogen peroxide could be explained in terms of free radical reactions, which are initiated by "Kramer electrons". It is as yet uncertain, however, whether the transfer of electrons occurs as a homogeneous or as a heterogeneous process. The same uncertainty exists about the Kramer effect, which is likely to be one of the sources of the electrons. Further research on these problems is being undertaken.

Though fundamental in character, the work of the Lubrication and Wear Division on freshly abraded surfaces is expected to yield information of importance in the formulation and application of lubricants, and also to contribute to a better understanding of the mechanism of operation of cutting fluids.

REFERENCES

1 Kramer, J., 1949, *Z. Phys.*, **125**, 739; 1950, *ibid.*, **128**, 538; 1951, *ibid.*, **129**, 34.
2 Russell, W. J., 1897, *Proc. Roy. Soc.*, **61**, 424; 1898, *ibid*, **63**, 102; 1899, *ibid.* **64**, 409; 1906, *ibid.*, **78**, 385; 1908, *ibid.*, **80**, 376.
3 Shaw, M. C., 1948, *J. Appl. Mech.*, **15**, 37.
4 "Mechanical Engineering Research 1952," p. 17 (H.M.S.O.)
5 Grunberg, L, and Wright, K.H.R., 1953, *Nature*, **171**, 890.
6 Grunberg, L. 1953., *Proc Phys. Soc.*, Lond. B, **66**, 153.

Meeting Diary

Continued from page 114

1st April

Institute of British Foundrymen (Tees-Side Branch) Annual General Meeting. Presentation of Awards—Apprentice Competition followed by "Any Questions." Question Master: F. Shepherd. Teesdale Hall, Head-Wrightson & Co., Ltd., Thornaby-on-Tees. 7·30 p.m.

2nd April

Institute of British Foundrymen (Newcastle Branch). Annual General Meeting and "Exothermic Feeding Heads," by W. Stewart. Neville Hall, Westgate Road, Newcastle-upon-Tyne. 6 p.m.

5th April

Institute of Metal Finishing (Midland Branch). "Bright Nickel Plating," by A. Smart, H. J. Bache and D. R. Newman. James Watt Memorial Institute, Great Charles Street, Birmingham, 3. 6.30 p.m.

Sheffield Metallurgical Association. "Safety in the Laboratory," by Dr. L. J. Burrage. B.I.S.R.A. Laboratories (Sheffield Group), Hoyle Street, Sheffield, 3. 7 p.m.

6th April

Institute of Welding (East of Scotland Branch). Annual General Meeting and Demonstration Night. Ramsey Technical College, Portobello. 7 p.m.

Institute of Welding (Manchester Branch). Annual General Meeting. Film Night. Films: "Running Order" and "Electric Resistance Welding." Reynolds Hall, College of Technology, Manchester. 7.15 p.m.

A Metallurgist Looks at Productivity*

By Hugh O'Neill, M.Met., D.Sc., F.I.M.

Professor of Metallurgy in the University College of Swansea

TEACHERS of metallurgy in universities are at present engaged in the increased production of technologists as demanded from several quarters. In general one feels that industry should examine its conscience as to whether the main requirement in Britain to-day is not more trained technicians and observers, rather than an increased production of expensively-trained specialist graduates. It might possibly be desirable to let the best students have more time to handle their subjects and cultivate their imaginations, in order that new advances in knowledge might develop more frequently. Perhaps one may mention that the biographer of Samuel Morse (of telegraph fame) wrote that this inventor's life had " not the slick look of advertisement, nor the glassy stare of ordered research, but the bloody look of creation ! "

Be that as it may, everybody is asked to consider the increase of productivity, and the subject can be treated in two ways: firstly, as a current condition and, secondly, by trying to provide recipes for better results. One might volunteer some amateur reflections on the first aspect of the subject, whilst as a metallurgist one could discuss technological details in connection with the second.

Mechanisation

On looking out from the ivory tower of a university one becomes increasingly impressed by the restless inventiveness of man. This is part of his nature, and we salute it. It leads him to produce machines which are themselves indifferent as regards good or evil results, but which in the hands of promoters of industry inevitably change the pattern of life for many of us. Mechanisation has good and bad effects, but there is one criterion at least which to my mind makes its adoption seem justified. If one believes in the principle of defending the hearth and the nation against aggression, then the defence force must be supplied with weapons on a scale which is commensurate with that used by possible aggressors. Under present conditions this involves big industry and mass production, so that apart from the necessity of maintaining our food supplies and financial stability, everyone but the theoretical pacifist needs to be involved in mechanisation. The mechanical unit must not be too big, or production may prove to be relatively expensive and human relations suffer. Years ago I remember that cast iron railway chairs could be made at a better price in a manual foundry than in a mechanised one involving heavy overheads. To-day the difficulty is recruitment of workers to the old-fashioned foundry !

Once under way it is almost inevitable that the pace of these regimes will accelerate, for it is found that mechanisation and increased productivity generally bring increased prosperity. Productivity is a ratio, a speed, the amount produced per head in unit time, and it depends upon :—

(*a*) material factors, equipment, etc. ;
(*b*) organisation, planning, etc. ; and
(*c*) the goodwill of men.

* Based on a talk given by the author to a South Wales audience last year.

There are indications that modernisation of equipment can give 15% increased productivity, whilst psychological measures (such as improved social relations) may give a 20% improvement[1]. Economy of effort and better conditions of work make this development not unattractive to the workpeople, but it is recognised that the process may ultimately have a dehumanising effect. There are bound to be limits to increasing the activation energy, for whilst under special conditions we supply tots of rum to men going over the top, even the doping of racehorses is looked upon as being discreditable. Men may go to the dogs but we should not consider them just as greyhounds. It must of course be appreciated that many aspects of productivity now have a merciful aim and are intended to provide a liberating influence. Men co-operate with the movement because it can lead to improved wages, and there are the prospects of promotion to jobs free from the dulling effects of automatic work.

Man and Repetitive Work

Anxiety has already arisen concerning what man *can do* and what he *is*. The story of the earth indicates that the mastodons of past geological ages failed and passed away because their brains did not keep pace with the development of their bodies. Man is more than a mere brute, and his dignity is universally recognised in such modern documents as the Declaration of the Rights of Man. Increasing productivity generally means the development as far as possible of continuous processes, and the breaking down of these to repetitive simple tasks. What is the ultimate effect of such tasks on humanity ?

Every schoolboy knows that one common form of punishment is to be made to write out a lot of simple lines a large number of times. Punishment in prisons once comprised the repeated piling and unpiling of cast iron cannon balls. Another prison task was the picking of oakum. Both these practices have been condemned and discontinued as degrading to human beings, partly because the results were not commensurate with the involved expenditure of human labour. I have met men who would prefer to pick oakum rather than make mail-bags, but such men would not be considered to-day as very desirable types. We have some recent published evidence[2] of the attitude of employees to repetitive work, and it was found in the case of women that, provided the general morale is good, such work is not disliked. Delays and frustrations and too much constraint produce troubles, but extra pay is a great incentive, whilst some diversity in the work is generally welcomed.

Agriculture and Cyclic Activity

In this diversity we perhaps have a clue as to what is fitting for men. Whilst planners generally aim at continuous processes, we must recognise that in nature activity is cyclic. Nothing appears to be strictly continuous. Even quantum theory indicates that the energy involved in physical-chemical reactions is trans-

ferred in minute packets and not purely continuously. Nature provides a series of cycles—night and day, summer and winter. Agriculture is a primary occupation which contains many lessons. *Greedy* farming, without a cycle or rotation of crops has led to soil erosion. There can be nothing much more laborious than the weeding of a crop in a field, and it causes men to fly from the land, but the agricultural worker at least has the knowledge that this particular activity only goes on for a limited time, and that eventually he will see and perhaps benefit from the finished result of his labours. In the winter cycle the amount of work is reduced and there is an opportunity for other jobs and recreations. Surely if repetitive tasks have become necessary we might try to vary them during the year, and enable the finished result to be appreciated by those who have contributed towards it.

Similarly as regards constraints. The domestic cutlery industry of Sheffield which was disappearing when I was a boy, offered certain attractions to " the little master." His repetitive work of forging blades or cutting the teeth on file blanks was often done when it suited him, and sometimes his workshop was in his own garden not far from the inevitable pig-sty and chicken-run. He was an aristocrat rather than a proletarian. If there was an important cricket match at Bramhall Lane he would throw his hammer into the air, and *if* it did *not* fall to the ground, he would continue at work. Similarly I have spoken to jobbing German glass-blowers who operated in a shed in the orchard and drank their beer at night under the blossoming trees. Workmen would not now like a return to these actual arrangements, which had many bad qualities, but considering the modern facilities for the distribution of electric power it might be possible to develop domestic systems for the lighter industries. In any future planning, an economic chain of producers, distributors and consumers might be set up which would leave a certain amount of initiative and freedom to all. This liberty might result in increasing productivity.

Large Enterprises and Heavy Industry

Whilst there appears to be room for many experiments in light and fabricating industries, the capital demands of heavy industry require large enterprises. Greed has not been without its effects in the development of " goodwill erosion " in such industries, but the situation has now settled down in many countries to a dynamic equilibrium between Company and Union. A recent investigation[3] gives some conclusions about a particular organisation in U.S.A., and these are probably applicable to many firms in Britain. It is found that the worker has developed a dual allegiance to both Company and Union, and looks to both for his welfare. " Pride of work " is found to be uncommon, but the worker wishes to be treated with dignity and not to be admitted just as a machine tool. Here the welfare organisations can provide conditions which should increase productivity if they realise the true nature of man. As regards our own region it is encouraging to note that the University of Wales now enables students (at Cardiff) to graduate in the subject of Industrial Relations, and it is said to be the first College in Britain to do so.

The above investigation revealed that more than anything the decent worker desires steady employment, without layoffs and short time, and this conclusion will surely be endorsed by any of us who have experience of social conditions. When I was returning from U.S.A. during the depression of 1931, most of my fellow passengers in the steerage were men from the Ford plants of Detroit who had secured jobs in Russia. " Ford's rate per day is all right " they said, " but you seldom know for how many days per week." Apart from slacking, which is a form of stealing, the knowledge of steady employment, plus a wage incentive, should generally lead to high productivity and, therefore, to an amelioration of Britain's difficult economic position. How full employment is to be maintained does not come within the terms of this paper, but it probably involves an overall policy for each area with a common market, and is linked with the development of efficient technical processes, and so to the second aspect of our study.

Foundry Improvements

The work of the Anglo-American Council on Productivity is well known, and the reports of the 47 industrial and 19 specialist teams include 13 which deal with metallurgical processes and operations. Another one covers " Education for Management " and a fifteenth is entitled " Universities and Industry." Four of the reports deal with the casting of various alloys, and their recommendations have already given definite results in Britain. The installation of more sandslingers in foundries, together with improved layout, better servicing of the moulder and improvement of working conditions (including dust extraction and cupola platform ventilation) have all contributed to produce more good castings in each unit of working time. The British Cast Iron Research Association has been a great help to its members in these matters, and compares very favourably with any organisation yet existing in U.S.A. Improvements in the industry did not have to wait for Productivity Teams, for many of the iron and steel foundries erected during the last war showed great advances.

The thermal economies which would result from the production of castings direct from blast furnace metal (as at Pont-à-Mousson in France) have not outweighed anxieties about variations in the quality of the iron, but a new *continuous* iron foundry at Turin deserves a mention. Pig is melted in direct arc furnaces and then transferred to other arc furnaces for chemical and temperature adjustment, after which the refined iron is stored in holding furnaces[4].

In the manufacture of steel castings, the British Iron and Steel Research Association has shown that improvements result if the air blown into the Tropenas converter is enriched with industrial oxygen. This Association is also promoting the establishment of a full-size plant for the continuous casting of steel billets. Meanwhile it is reported from Russia[5] that 38 firms are already producing sheet metal by direct casting.

Specifications

One way of increasing productivity is to make less scrap and fewer wasters. This can be done by :—

(*a*) scrutinising specifications so that they do not ask for more than is really required ;
(*b*) increasing the intelligence of inspection so that it combines justice with realism ;
(*c*) improving operational control so that malpractice and wastage are checked ; and

(*d*) utilising research and scientific methods so that new life may come into the works.

Examples covering these points will occur to most of you, and under (*a*) and (*b*) one or two cases will be mentioned.

When I was a railway metallurgist, an old friend, Mr. Harry Brearley (the famous analyst and discoverer of stainless steel) wrote to me about narrow specifications for steels. He was thinking of impurity limits of 0·05% and his letter dated January 6th, 1946 ran as follows :—

"... the great outlet for Bessemer steel was as a substitute for wrought iron for the Railways. My analyses of the old tyres made between 1870–80 showed sulphur up to 0·188% and phosphorous up to 0·121% with carbon and manganese all over the shop. I should say there was no specification, and the tyres were not much worse for the lack of a specification. ... The Railways more than any other large user were deluded by the chemical analyses tales. Most of the tales were started by chemists who felt they had to do something to justify their jobs. The tales were repeated by steelmakers when it suited them and were defended in Specification Committees by railway members against the evidence of their own experience for jurisprudence reasons ... I am not saying that chemistry and specifications are useless but I am saying they have been misused."

These are the considered views of a steelmaker who did not have the responsibility of using the steels, but he also told me of another state of affairs which many years ago unnecessarily reduced productivity. Railway tyres as they come from the mill have to pass a mechanical drop test before acceptance by the user. Brearley proved that some specification demands were irrational, for tyres which had been accepted would not pass the test after the user had machined the bore surfaces. The machining at that time left such a bad finish that the extra operation cancelled the properties which had been demanded of the producer.

I can remember a retardation and wastage during the war which arose in connexion with certain heat-treated forgings. These carried an integral test block which because of mass-effect could never meet some curious mechanical test requirements. Every batch of forgings had to be given a wasteful repetition of the treatment, but they always passed the second time. This was because only half the test block remained for the repeat operation, and its reduced mass-effect enabled the required test figures to be reached. The actual forgings, of course, were in just about the same condition as after the first quenching and tempering!

"Initial" versus "Overall" Productivity

Under (*c*) and (*d*) above one can think of examples in relation to welding. Welding processes in many cases can lead to what I would call increased "initial" productivity, but for important jobs they require considerable supervision. If this is shirked the finished assemblies may come to grief, and may cause trouble and delays and expenditure on repairs. In this case the "overall" productivity will be reduced. Metallic arc welders may do much harm if they do not keep to the rules when working on the higher tensile steels. The laying down of quickly-made small weld beads, the production of small weld tacks in the wrong places, and the starting-up of new electrodes on the parent structure may all produce hard and brittle regions on the assembly which can lead to rapid cracking and rejection. Under service conditions of alternating stress, however, trouble may only arise after a year or more, due to fatigue of the joints. Then it comes in a flood, and the results are depressing. X-ray and gamma ray inspection of welds can teach some useful lessons which will lead to greater output, and it is an advantage if the workmen can see the results of these tests so as to set themselves a standard. I was involved in applying X-ray testing to difficult repairs in locomotive frame plates, and by organising a mobile radiography unit we were able to let the welders at different works improve their technique, so that the period of repair was greatly reduced.

Improvements in Smelting and Refining Operations

A recent survey[6] has shown that the present world position regarding metallic ores is one of very limited supply in many of the old fields, but prospectors have discovered so much new material that the position for the near future is not disquieting. At the same time attention is being paid to the utilisation of leaner ores and to the sintering of fine ores which would otherwise be wasted. On the research side it may be mentioned that aerodynamic study of a certain British sinter plant has enabled its output to be increased by 66% above the original expectation. Mining methods are being developed to give increased output, as at the nickel mines in Sudbury, Ontario. The application of research at the Clydach refinery of the Mond Nickel Company has enabled output to be greatly increased, and improved methods of producing zinc are now available. Flash roasting and smelting are being developed for many ores, and modern gaseous processes for carburising steel and malleablising cast iron have advantages over those where the reactions are produced after laboriously packing the articles with solid reagents in boxes.

The speed of refining operations can sometimes be increased indirectly, if rapid methods of chemical analysis are available to release a batch of finished metal. Spectrometric methods, as by the Quantometer, are very quick and labour saving. Polarographic methods installed in a scrap reclamation depot enabled us to bring the composition of baths of metal to specification, where previously they had followed the slow procedure of being tapped, remelted and "doped" to the desired analysis.

Productivity in steelmaking can be increased along the lines given in the Report of the Iron and Steel Productivity Team. Two papers just published by the Swansea and District Metallurgical Society[7] indicate how the open-hearth process may be improved in this respect. The first deals with the appraisal and selection of refractory materials, whilst the second shows how increased rates of furnace charging and melting-down have given better results.

The Basic Bessemer Process

In the future Britain will have to consider a greater use of the basic Bessemer method, especially as steel scrap is becoming more expensive. This process was devised in South Wales by Thomas, and a charge of molten crude metal can be blown down into good steel in about 20 minutes. The usual British fixed basic open-hearth furnace using a liquid charge can produce

TABLE I.—THOMAS STEEL PRODUCTION IN VARIOUS COUNTRIES EXPRESSED AS A PERCENTAGE OF TOTAL PRODUCTION

Country	Percentage	Remarks
Luxembourg	100	Out of the 50 million tons total steel production in these countries, 16·5 million tons, or 33%, is Thomas Steel.
Belgium	85	
France	60	
Germany	40	
U.K.	5	
U.S.A.	0	

just over 1,000 tons of steel per week, whereas 3 basic Bessemer converters will produce 6,000 tons in the same time. Table I[4] indicates the high percentage of their steel output which is made in certain Continental countries by this process.

In Anglo-Saxon countries there have been fears about the quality of some of this steel, but recent Continental developments have reduced its dissolved nitrogen to very low values, whilst spectrographic methods of blowing control have been refined. In one modification the injected air is mixed with oxygen and carbon dioxide, whilst in another steam replaces the latter gas. The Thomas process admits of roughly doubling productivity, and of giving very good steel.

Helping the Production Engineer

To conclude this review mention will be made of one or two finishing operations for metals. Grinding can do a lot of harm to otherwise good products, and I have seen numerous large gear wheels ruined by too rapid grinding. The heat produced superficially causes transformations in the steel, which involve volume changes and the production of shallow cracks. The bad effects of such impatience can be mitigated if the compositions of the steels are kept within certain limits.

The metallurgist can help to improve productivity by providing (*a*) durable tools, and (*b*) metals of increased machinability. Speed effects are involved, and the behaviour of a boring tool is well conveyed in the mediæval lines :

" Fast to run into the wood
And bite I shall with mouth full good."

For a given hard tool the principles of machinability are now fairly clear, and the factors involved include :

(*a*) the metal-physics of lubrication with the accompanying temperature effects ;
(*b*) a type of microstructure in the stock which will give brittle chips and borings ; and
(*c*) the work-hardening capacity and hardness of the stock at various speeds and temperatures.

As regards microstructure, the early Bessemer steels often contained numerous elongated non-metallic inclusions, and these caused a break-up of chips and borings and thus cleared the tool for active work. Suitable inclusions are therefore now deliberately provided in free-cutting metals, and additions of lead (say 0·2%), selenium, sulphur etc., produce a great effect.

TABLE II.—MACHINABILITY OF BRASS
(Desch and O'Neill)
" Apparent Zinc " about 40%

Drilling Time sec.	Indentation Test		Condition	Lead %
	Work Hardening factor—*n*	Hardness *Pu*		
40*	2·49	236	Extruded	0·99
40	2·13	162	Rolled	0·64
31	2·36	156	Cast	0·66
30	2·31	148	Cast	1·95
27	2·26	118	Extruded	1·99
25	2·14	154	do. Fibrous	1·54

* 43·5% apparent zinc. At high speeds was 10 times worse than the best alloy.

The advantages of a fibrous or banded arrangement of the microstructure in an alloy having two constituents was published by Desch in 1920[8]. During the first war the output of some cutting machines dealing with 60/40 brass bars would vary by more than 40%, and Desch found that this was not primarily due to variations in Brinell hardness. He concluded that a composition of 40% " apparent " zinc was desirable, with an arrangement of fine, fibrous *alpha* crystals, separated by a small quantity of the second *beta* constituent.

The author had the opportunity of carrying out ball indentation tests on some of Desch's specimens, and determined the Meyer index *n*, which is highest in materials having a high capacity for work-hardening. A ball hardness value *Pu*, which incorporates a definite strain-hardening component, was also determined, and the results given in Table II were published in 1928[9]. Considering all the factors it can be stated that for a given amount of chip-breaking content (e.g., lead) and for a given microstructure, the lower the Meyer *n* value the greater is the machinability of the metal. For a given *n* value, machinability would probably decrease with increase of ultimate harness *Pu*. These effects were summed up by E. G. Herbert in the statement that machinability is directly related to the hardness of the cold-worked chip produced during machining. Similarly, initial cold-working, by reducing the *n* value, would tend to improve machinability.

These views fit in very well with the observation that a fine spheroidised microstructure permits of more rapid cutting than one in a laminated or spikey form. The pearlite constitutent of steel can be annealed so as to convert the microscopic carbide plates into rounded globules, and so improve machinability. The present author showed in 1943[10] that this treatment also produces a fall in the Meyer *n* value.

There is of course a great tendency to try and reduce the amount of time spent on machining operations by eliminating them altogether if possible. Various forms of precision casting can produce a complex and finished article direct from the mould or die, and the " lost wax " process of the ancients has been revived in recent years for gas turbine blades. Pressure welding enables one to make complicated assemblies very rapidly, whilst the extrusion of metals by impact or by slower pressures can produce long lengths of finished section having intricate contours. These aspects of fabrication metallurgy are receiving increased attention.

The technical side of this subject could be treated more extensively, but I would now return to the thought that the human aspect must eventually be paramount. Productivity must fit into human good, whether one agrees or not with the view expressed by the character in *Candida* that " We have no more right to consume happiness without producing it than to consume wealth without producing it."

REFERENCES

1 " Le Problème Humain de la Productivité," E. Rideau, *Echo de l'U.S.I.C.*, Jan., 1955.
2 " Women's Attitudes to Repetitive Work," Report by National Institute of Industrial Psychology, 1953.
3 " The Worker Speaks his Mind on Company and Union," T. V. Purcell, Harvard University Press, 1954.
4 *Metal Progress*, Jan., 1954.
5 *The Times*, Feb, 10th, 1954.
6 Metal Economics, *J. Inst. Metals*, Jan., 1952.
7 Swansea and District Metallurgical Society, Prize Essays, 1953.
8 Desch, C. H., *J. Soc. Chemical Industry*, 1920, **39**, 216 T.
9 O'Neill, H. *Iron and Steel Inst. Carnegie Memoirs*, 1928.
10 O'Neill, H., *Proc. I. Mech. Engrs.*, 1943, **149**.

The Properties of a High-Manganese Austenitic Stainless Steel

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It is shown that although in some media the corrosion-resisting properties of a stainless steel containing 18% chromium, 10% manganese, 2% nickel, stabilised with titanium, are equal to those of a titanium-stabilised 18-8 chromium-nickel steel, there are many industrial applications for which the high-manganese steel would not be suitable. The ductility and deep-drawing properties of the high-manganese steel are inferior to those of the 18-8-titanium type.

IT is well known that among the elements which promote retention of austenite in stainless steels at room temperature are carbon, nitrogen, nickel, manganese and copper. Of these elements, nickel is the most widely used, but manganese has also been employed by some steelmakers for the manufacture of austenitic stainless steels. This article presents a comparison of the properties of a modified stainless steel containing 18% chromium, 10% manganese, and 2% nickel, stabilised with titanium, with those of a titanium-stabilised 18-8 chromium-nickel steel, and those of a ferritic steel containing 17% chromium, which has been used in some applications as a substitute for the 18-8 type of steel.

Materials Tested

The analyses and thicknesses of the steel sheets examined are given in Table I. The corrosion-resisting properties of the three steels, in the annealed condition, were compared, and determinations were made of some of the physical properties of the manganese stainless steel and of the 18-8-titanium steel, both being tested in the annealed condition.

TABLE I.—COMPOSITION OF MATERIALS TESTED.

Material	Thickness in.	Composition—%						
		C	Si	Mn	Cr	Ni	Ti	N
18 Cr/10 Mn/2 Ni/Ti	0·036	0·08	0·44	10·5	17·5	1·9	0·59	0·012
17 Cr	0·040	0·05	0·47	0·84	17·7	trace	0·002	—
18 Cr/8 Ni/Ti ..	0·038	0·10	0·63	0·47	18·2	8·1	0·58	—

TABLE II.—TENSILE PROPERTIES OF THE STAINLESS STEELS.

Material	0·2% Proof Stress tons/sq. in.	0·5% Proof Stress tons/sq. in.	Ultimate Tensile Strength tons/sq. in.	Elongation on 2 in. %	Hardness D.P.N.
18 Cr/10 Mn/2 Ni/Ti	33·1	36·1	49·1	26·5	238
18 Cr/8 Ni/Ti	19·0	22·0	47·0	57·5	203

Physical Properties

(*a*) *Tensile Properties*

The tensile properties and hardness values of the manganese and 18-8-titanium steels are presented in Table II. The manganese stainless steel showed better proof stress and higher hardness values than the 18-8-titanium steel, and its tensile strength was slightly higher. The greatest difference in tensile properties of the two steels was in ductility, the 18-8-titanium steel having an elongation of about 55%, whereas that of the manganese stainless steel was only about 30%.

(*b*) *Deep-Drawing Properties*

The deep-drawing properties of the manganese stainless steel were compared with those of the 18-8-titanium steel, by tests made in a cupping machine similar to that described by Swift[1]. The results of these tests are given in Table III and the test pieces are shown in Fig. 1. The 18-8-titanium steel sheet was successfully "cupped," using the conditions noted in Table III. Although a

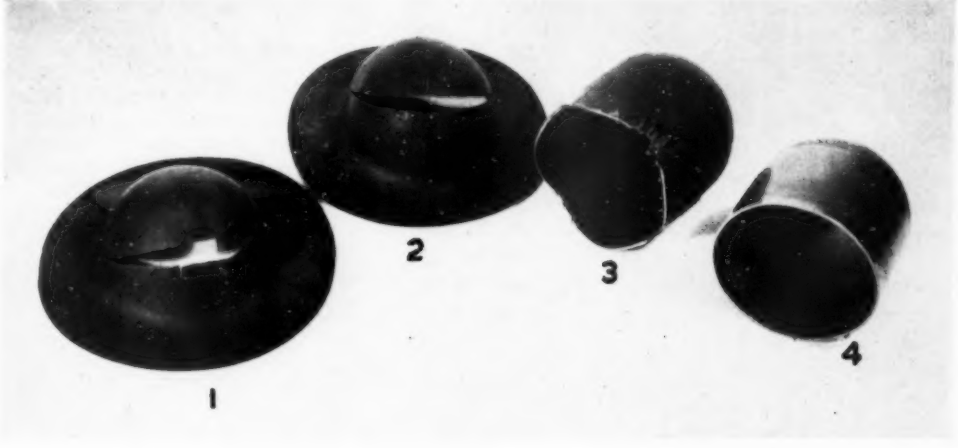


Fig. 1.—View of the test pieces after the deep-drawing tests. Nos. 1, 2 and 3 are 18 Cr/10 Mn/2 Ni/Ti steel, and No. 4 is 18 Cr/8 Ni/Ti steel. × Approx. ½

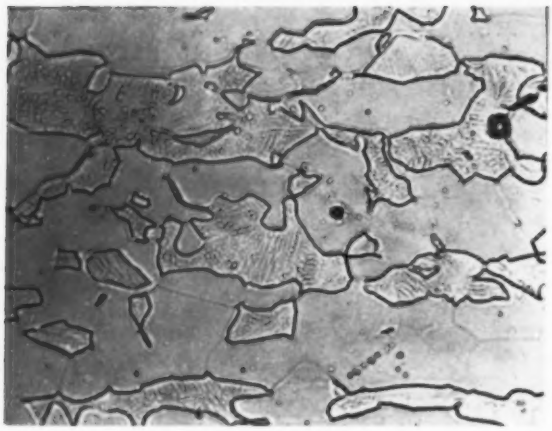


Fig. 2.—Annealed structure.

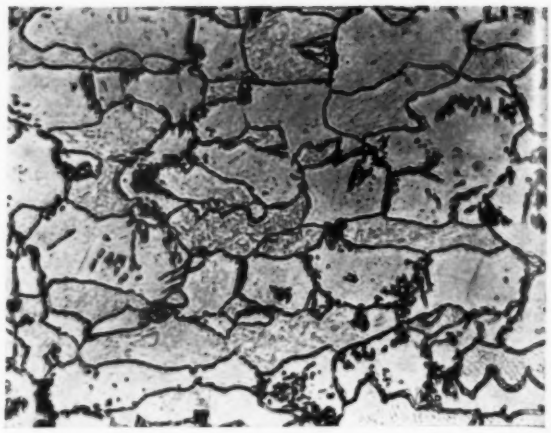


Fig. 3.—After 2 hours at 650° C.

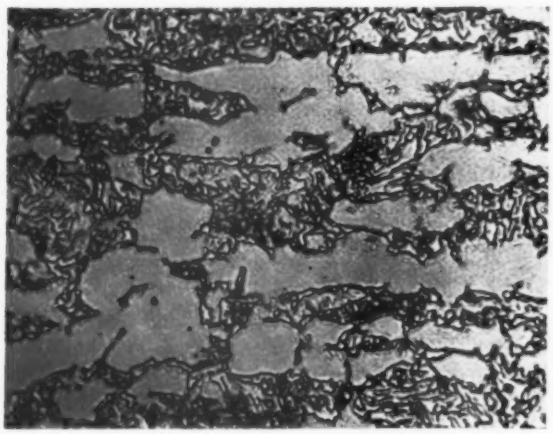


Fig. 4.—After 16 hours at 650° C.

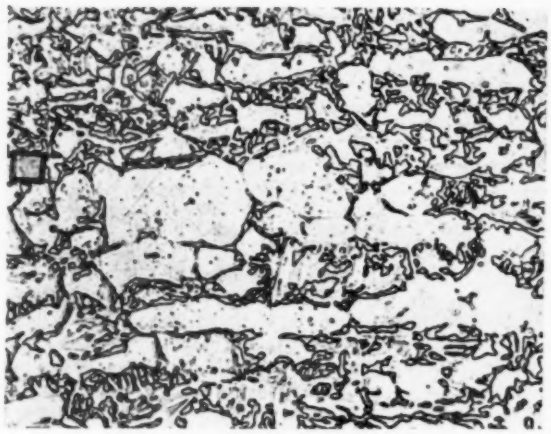


Fig. 5.—After 48 hours at 650° C.

Figs. 2–5.—The effect of time at 650° C. on the precipitation of sigma phase in the manganese stainless steel. (Etched electrolytically in 5% hydrofluoric acid, 10% glycerol solution). × 750

number of tests using less severe conditions were made on the manganese stainless steel, the blank-holding pressure was reduced to 40 lb./sq. in. before a test piece was drawn, and even in such conditions very bad crimping occurred. (See Fig. 1). Because of damage to the die the deep-drawing tests on this steel were discontinued.

(*c*) *Effect of Reheating upon Structure and Embrittlement*

The structure of the manganese stainless steel, shown in Fig. 2, consisted of approximately 50% ferrite and 50% austenite, with inclusions of titanium carbonitride. This structure was not affected by reheating at 850° C. for any time up to 1,000 hours, nor was any embrittlement detected by means of simple reverse-bend tests. Reheating at 650° C. however, resulted in the precipitation of *sigma* phase: the transformation took place initially at the boundaries between ferrite grains, and, with progressive increase in time at 650° C., spread across the ferrite grains. Figs. 3, 4 and 5 illustrate the changes in microstructure which occurred on reheating the annealed steel at 650° C. for 2, 16 and 48

TABLE III.—RESULTS OF DEEP-DRAWING TESTS.

Material	Specimen No. (see Fig. 1)	Diameter of Test Piece in.	Blank Holding Pressure lb./sq. in.	Maximum Ram Pressure lb.	Result of Test
18 Cr/10 Mn/2 Ni/Ti	1	4·1	240	1,000	Failed
	2	4·2	140	1,100	Failed
	3	4·2	40	1,150	Passed, but with very bad crimping
18 Cr/8 Ni/Ti	4	4·1	240	1,250	Passed

TABLE IV.—EFFECT OF REHEATING AT 650° C. ON THE PROPERTIES OF THE MANGANESE STAINLESS STEEL.

Time at 650 °C. (hr.)	Result of Bend Test	Hardness D.P.N.	Corrosion Rate in Boiling 65% HNO_3		Ferromagnetism
			m.d.d.*	i.p.m.†	
0	180° bend—no cracks	201	566	0·0085	Magnetic
2	180° bend—no cracks	216	1368	0·0204	Magnetic
16	Broke after slight bend	306	2695	0·0404	Slightly magnetic
30	Broke after slight bend	309	3893	0·0582	Slightly magnetic
48	Very brittle	337	1600	0·0239	Slightly magnetic

* m.d.d. = milligrams/sq. dm./day. † i.p.m. = inches penetration per month.

hours. Formation of *sigma* was confirmed by X-ray examination of filings taken from the sample which had been treated for 48 hours at 650° C. As would be anticipated[2], precipitation of *sigma* within the ferrite grains was accompanied by severe embrittlement, substantial increase in hardness, reduction in ferromagnetism, and decrease in resistance to corrosion by nitric acid (see Table IV). It will be noted from the table that some recovery in resistance to nitric acid occurred after reheating for 48 hours at 650° C. Similar behaviour has been observed when *sigma* has precipitated in molydenum-bearing stainless steels[3].

Corrosion-Resisting Properties

(*a*) *General Corrosion*

Test specimens in the form of discs 25 sq. cm. in area were obtained from sheet of all three steels. The specimens were prepared by hand-grinding on emery paper, and washed, dried and stored for 24 hours before use.

Fig. 6.—Circular-path corrosion-test apparatus.

The results of tests in boiling 65% nitric acid are given in Tables IV and V. It will be noted from Table V that in this solution the manganese stainless steel, in both the sensitised and the annealed conditions, was distinctly inferior to the 18-8-titanium and 17% chromium steels, although the rate of attack of the 18-8-titanium steel was somewhat higher than is normally obtained. In resistance to corrosion by boiling phosphoric acid solutions, the 18-8-titanium steel showed to slight advantage (Table VI), but there was little to choose between the 17% chromium and manganese stainless steels.

Further tests, in solutions of mildly corrosive acids and inorganic salts, were carried out in the circular-path corrosion-test machine shown in Fig. 6. Under these conditions, in which the specimens were given a uniform circular motion of 6·25 ft./min., the three materials remained passive in aerated solutions of 50% acetic acid, 25% citric acid, 50% phosphoric acid and saturated ammonium alum, at temperatures of 30° C. and 50° C.

The relative resistance of the steels to attack by stagnant solutions of sulphurous acid and inorganic chlorides was also determined. In saturated sulphurous acid at room temperature the 17% chromium steel either became perforated or suffered very severe local attack within two days' exposure. The 18-8-titanium and manganese stainless steels remained passive in this medium, even although slight atmospheric oxidation of the sulphurous acid to sulphuric acid occurred during the test period of 60 days. In 5% aluminium chloride solution specimens of all three materials remained passive during a test period of 60 days, but in 10% zinc chloride solution the manganese and 17% chromium steels lost their passivity and began to corrode after 40–48 days' exposure.

The results indicate that, with the exception of sulphurous acid, the corrosion-resistance of the manganese stainless steel was similar to that of the 17% chromium steel, but somewhat inferior to that of the 18-8 steel.

(*b*) *Resistance to Crevice Attack*

For this test small panels of each steel were prepared by hand grinding and then pickled in hot 25% nitric acid/10% hydrofluoric acid solution. After washing, drying, and storing for 24 hours, glass rods were placed on each panel and a small amount of an aqueous solution of 4% sodium chloride/1% lactic acid was dropped around each rod. After 18 days' exposure, rusting had begun around all the glass rods on the manganese stainless steel, and after 45 days' exposure the 17% chromium steel also started to rust underneath the glass rods. The 18-8-titanium steel remained unaffected after 60 days' exposure.

(*c*) *Atmospheric Corrosion*

The surfaces of panels (8 in. × 6 in.) of the three steels were prepared (*a*) by hand-grinding and pickling in hot 25% nitric acid/10% hydrofluoric acid solution, and (*b*) by grinding to a dull mirror polish. The panels were mounted at an angle of 60° to the horizontal and exposed to the industrial atmosphere of Birmingham. The specimens soon acquired a deposit of soot and grime, and after a few weeks' exposure the manganese stainless steel having a pickled surface showed extensive rusting, while only a few isolated points of rusting were evident on the 17% chromium steel. The 18-8-titanium steel specimens of similar surface finish were fogged but

TABLE V.—RESISTANCE OF THE STAINLESS STEELS TO CORROSION BY BOILING 65% NITRIC ACID.

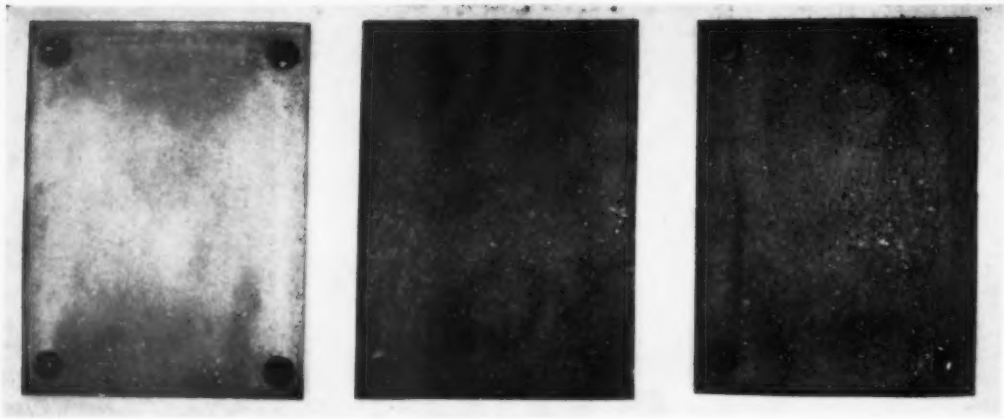
Material	Condition	Corrosion Rate	
		m.d.d.*	i.p.m.†
18 Cr/10 Mn/2 Ni/Ti ..	Annealed	566	0·0085
	Sensitised 2 hr. 650° C...	1368	0·0204
17 Cr	Annealed	118	0·0017
	Sensitised 2 hr. 650° C...	131	0·0019
18 Cr/8 Ni/Ti	Annealed	170	0·0025
	Sensitised 2 hr. 650° C...	546	0·0081

* m.d.d. = milligrams/sq. dm./day. † i.p.m. = inches penetration per month.

TABLE VI.—RESISTANCE OF THE STAINLESS STEELS TO CORROSION BY BOILING PHOSPHORIC ACID.

Material	Corrosion Rate (m.d.d.)			
	10% H_3PO_4	20% H_3PO_4	30% H_3PO_4	40% H_3PO_4
18 Cr/10 Mn/2 Ni/Ti ..	10	17	18	27
17 Cr	3	6	11	16
18 Cr/8 Ni/Ti	6	6	8	2

m.d.d. = milligrams/sq. dm./day.



(a) (b) (c)

Fig. 7.—Appearance of specimens after exposure to an industrial atmosphere for 18 months : (a) 18 Cr/8 Ni/Ti steel ; (b) 17 Cr Steel ; (c) 18 Cr/10 Mn/2 Ni/Ti steel. × $\frac{1}{4}$

showed no rust. After seven months' exposure the manganese stainless steel was completely rusted and extensively pitted ; the 17% chromium steel showed patches of rust but rather fewer pits, and the 18-8-titanium steel was also pitted (to rather less extent than the 17% chromium steel) and slight rusting was evident around the pits. The appearance, after 18 months' exposure, of the underneath surfaces of the specimens having pickled surfaces is shown in Fig. 7. The specimens having polished surfaces did not rust so rapidly as those with pickled surfaces, but the order of merit remained the same. At the end of the test periods the corrosion product was removed by treatment with warm dilute nitric acid and the depth of pitting was estimated by microscopic methods. The results of this examination are given in Table VII. The pits on the manganese stainless steel were much wider than those on the other two materials, although the depth of pitting was less than on the 17% chromium steel. In consequence, the average rate of corrosion as determined by weight-loss measurements was substantially greater for the manganese stainless steel than for the 17% chromium and 18-8-titanium types.

The results indicate that from the viewpoint of appearance the manganese stainless steel is inferior to the 17% chromium and 18-8-titanium steels, but that it is more resistant than the 17% chromium steel to penetration by atmospheric corrosion.

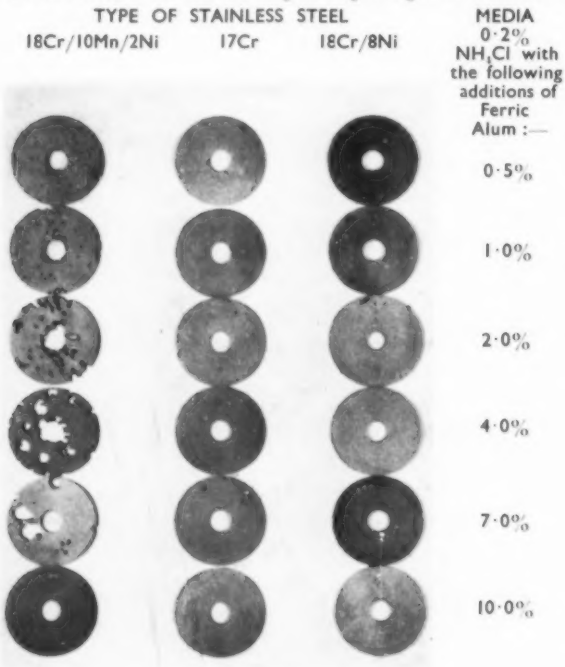


Fig. 8.—Comparative resistance of stainless steels to pitting.

(d) Resistance to Pitting

The relative resistance of the stainless steels to pitting was assessed by means of the following method, developed in The Mond Nickel Company's Research Laboratory. Results obtained by it on other stainless alloys have shown good correlation with ratings made on the basis of industrial experience.

As is well known, the exposure of stainless steel to solutions containing ferric ions (or certain other metal ions having two valency states) in conjunction with chloride ions can rapidly lead to severe pitting of the material. The addition of a sufficient amount of an oxidising agent, such as nitrates, chromates, ferric and other ions, to the solution will, however, inhibit attack. Hence, it follows that it is possible to grade the pitting-resistance of stainless steels on the basis of the minimum

TABLE VII.—RESISTANCE OF THE STAINLESS STEELS TO CORROSION BY AN INDUSTRIAL ATMOSPHERE

Material	Condition of Surface	Duration of Test (days)	Average Rate of Corrosion m.d.d.	Maximum Depth of Pitting (in.)		Average Number of Pits/sq. cm.	
				Upper Surface	Lower Surface	Upper Surface	Lower Surface
18 Cr/10 Mn/2 Ni/Ti ..	(a) Pickled	566	—	0·002	0·0035	20	18
	(b) Polished	510	0·23	0·003	0·003	20	25
17 Cr	(a) Pickled	566	—	0·003	0·005	10	30
	(b) Polished	510	0·09	0·005	0·0045	10	30
18 Cr/8 Ni/Ti..	(a) Pickled	566	—	0·002	0·0015	5	2
	(b) Polished	510	0·06	0·003	0·001	12	10

m.d.d. = milligrams/sq. dm./ day.

amount of oxidising agent necessary to prevent pitting One method of applying this principle consists of exposing the stainless material to chloride solutions containing progressively increasing amounts of ferric ions.

For the present purpose the most suitable solution was considered to be one containing 0·2% ammonium chloride, to which additions of 0·5%, 1%, 2%, 4%, 7% and 10% of ferric ammonium sulphate were made. Disc specimens were carefully prepared in the same manner as in the crevice attack tests, and four discs of each material, i.e., a total of 12 specimens, were immersed in 6 litres of each of the above solutions. The circular-path machine was used for the tests and the solutions were maintained at a temperature of 30° C. After exposure for four days the specimens were removed, washed, dried and examined for signs of pitting.

The result of this test is shown in Fig. 8, from which it will be noted that whereas 4% of ferric ammonium sulphate was sufficient to passivate the 18-8-titanium steel, more than 7% was needed to passivate the 17% chromium and the manganese stainless steels. It will also be seen that with increasing concentration of ferric ions up to the passivating limit there was a general tendency for the pits to become fewer and deeper, and that at a given ferric-ion concentration below the passivating limit the manganese stainless steel pitted more profusely than the 17% chromium steel, while the latter pitted more profusely than the 18-8-titanium steel. It is clear from these tests that the 18-8-titanium steel is much superior in pitting resistance to the 17% chromium steel, and that the latter is slightly more resistant to pitting than the manganese stainless steel.

Effect of Welding on Manganese Stainless Steel

Stainless steel equipment is frequently fabricated by welding, which renders the material near to the welds susceptible to intergranular attack, unless the steel is of very low carbon content or is adequately stablised by addition of niobium or titanium. The susceptibility of stainless steel to intergranular attack is frequently determined by exposing welded specimens or heat-sensitised specimens to corrosion by boiling copper sulphate/sulphuric acid solution.

Cross-welded specimens of the manganese stainless steel were therefore prepared by gas welding, using standard filler rods of 18-8 niobium-stabilised steel and tested in a boiling acidified solution of copper sulphate. Exposure to this solution did not lead to any significant corrosive attack as determined by microscopic means.

The micro-examination of the welded manganese stainless steel revealed that excessive grain growth had occurred in the vicinity of the welds. The structure of the coarse-grained zone consisted wholly of austenite, the ferrite having been taken into solution by the welding treatment. There was also a progressive diminution in the amount of titanium carbo-nitride present in the structure on passing from the unaffected sheet metal to the weld metal, indicating that carbon had been taken into solution.

At a high magnification the presence of small hard particles could be observed, both at the grain boundaries and within the grains of the sheet material adjacent to the weld. The structure as developed by relief polishing, is illustrated in Fig. 9. It will be noted that the material adjacent to the grain boundaries is relatively free from precipitate, and in view of this feature, and of the

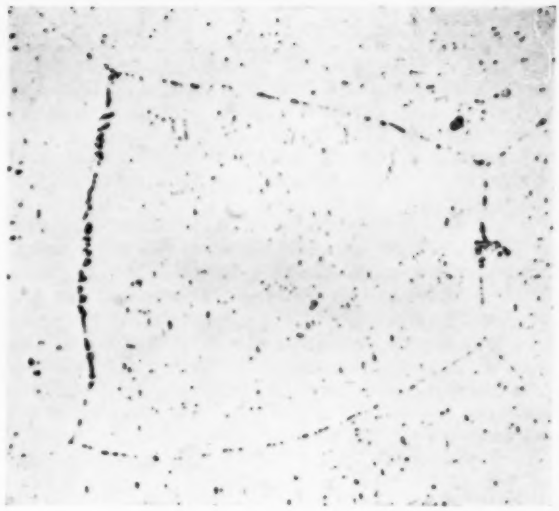


Fig. 9.—Precipitation of carbides at grain boundaries and within the grains in sheet material adjacent to welds. (Unetched, relief polish). × 750

solution of titanium carbo-nitride which occurred in this zone, it seems probable that the small particles are chromium carbides which have been re-precipitated on cooling from the welding temperatures.

Conclusion

The tests reported have shown that the ductility and deep-drawing properties of the manganese stainless steel are inferior to those of the 18-8-titanium steel, due, probably, to the mixed austenite/ferrite structure of the manganese steel. The addition of further manganese or nickel to the titanium stabilised 18% chromium 10% manganese, 2% nickel composition would result in a fully austenitic steel, which would be expected to have ductility similar to that of the 18-8 chromium-nickel steel. The manganese stainless steel does not withstand so extensive a range of corrosive media as the 18-8 chromium-nickel steel, but it does offer good resistance to corrosion by many solutions encountered in industrial service, and it would be suitable for applications in which such solutions are involved, and in which the requirement is for an austenitic or semi-austenitic stainless steel having corrosion-resistance approximately of the same order as that of the straight-chromium steels.

Acknowledgment

The authors wish to thank The Mond Nickel Co., Ltd., for permission to publish this article.

REFERENCES

1 Swift, H. W. Instn. Automob. Eng. Symposium on Deep-Drawing Research, 1940, pp. 1–73.
2 Smith, L., and Bowen, K. W. J. *Jnl. Iron and Steel Inst.*, 1948, **CLVIII** 295–305.
3 Binder, W. O., and Brown, C. M. Symposium on Evaluation Tests for Stainless Steels, Amer. Soc. Testing Material Spec. Tech. Publn. 93, 1949, 146–182.

G.W.B. FURNACES, LTD., announces that due to the continued expansion of its business, the Head Office (including the Accounting Section) was transferred to Dibdale Works, Dudley, on February 1.

New and Revised British Standards

Fine Resistance Wire for Telecommunication and Similar Purposes
(B.S.1117 : 1955) Price 2s.

This British Standard, which supersedes the War Emergency edition of 1943, applies to wires of circular cross-section, and of diameters in the range 0·0005 in. to 0·012 in. inclusive. It embraces four classes of metallic resistance materials based on the requirements of temperature coefficient of resistance, working temperature and non-tarnishing characteristics. It was considered impracticable to include resistance tables for the large range of materials covered by the scope of this standard, but requirements are stated for the tolerance on resistivity, resistance and uniformity of resistance. Maximum values for the temperature coefficient of resistance over given temperature ranges are specified for each of the four classes of resistance materials. Requirements are also laid down for the physical condition of wires as supplied by the manufacturer, and a mechanical test is specified for wires which are not ordered to a special temper by the purchaser. This standard is complementary to B.S.115 : 1954, which deals with metallic resistance materials for general electrical purposes.

Sizes of Manufacturers' Trade and Technical Literature (including Recommendations for Contents of Catalogues)
(B.S.1311 : 1955) Price 2s. 6d.

This standard has been prepared following requests from a number of important trade associations, chiefly in the engineering and building industries, and no less than 38 organisations took an active part in the work, which is designed to overcome two main difficulties. Firstly, when large plant is installed, one aspect of the contractor's work is simplified if he can furnish full working instructions to his customer by assembling into one binder all the working instruction sheets issued by sub-contractors and suppliers of ancillary equipment. This is often not practicable unless all the literature is of the same size and in any case a heterogeneous collection of sizes presents an untidy appearance that hardly constitutes a good advertisement.

Secondly, with catalogues, brochures and pamphlets similar considerations arise. The psychological aspect of this is particularly important for exports because sizes of literature have been standardised in many countries for years. In addition, even if there is no question of grouping with other publications, a great variety of shapes and sizes can become a considerable nuisance to librarians and others who wish to retain literature for reference. Some publishers deliberately produce brochures, etc., in non-standard sizes so that they should stand out from those of their competitors, but they may be thrown away because they are inconvenient.

The standard applies to all types of literature issued by manufacturers except "throw-away" publicity leaflets, although there is no reason against applying it also for these. Two sizes are provided and the choice will in practice be governed by requirements; both have the advantage that they can be cut from stock sizes of almost all the types of paper likely to be used.

Certain large undertakings had decided upon their own standards some years before this standard was suggested and much credit is due to them for this initiative. Unfortunately, the sizes adopted by them are often different from those of the British Standards, and where their size differs it may possibly be some little time before a change is possible. Nevertheless it is hoped that all organisations will recognise the desirability of adopting one of the standard sizes as soon as possible.

Control Chart Technique
(B.S.2564 : 1955) Price 10s. 6d.

This British Standard gives practical guidance on the use of quality control in all processes of manufacturing to a specification. Written by Dr. B. P. Dudding and Mr. W. J. Jennett, it was first published by the General Electric Co. Ltd., in 1944, and with the kind permission of the Director of the Research Laboratories of the G.E.C. it is now issued as a British Standard. The same authors intend to supplement B.S.600R, which is already well-known for its description of the statistical principle and methods used in quality control. The new standard is essentially a practical manual describing procedures which have been found acceptable when introducing and operating quality control methods as factory routine. Its major object is to assist production to a standard of quality, with the elimination of waste of labour and material.

The standard is divided into two parts. The first concerns the utilisation of results of measurement (quantitative data), and is of particular interest to manufacturing industry wherever articles or components are produced in quantity with dimensional limits of accuracy. The second part concerns the classification of a product by quality (qualitative data), and is of use wherever sampling technique can be applied to regulate production. The standard will also be of interest to those who are teaching the use of statistical methods. Directions are given for the construction and interpretation of control charts appropriate to various types of process and examples of some of the different cases met in practice are given.

Drums for Covered Winding Wires and Strips
(B.S.2565 : 1955) Price 2s.

At the present time many different sizes and types of drum are used for the supply of covered electrical winding wires and strips. There are many flange diameters and for each diameter several traverse dimensions. This causes considerable inconvenience, both to the wire coverers and to users in many different branches of the electrical industry. With the co-operation of these interests, the British Standards Institution has, therefore, published a standard for drums for covered winding wires and strips for electrical purposes for use in the United Kingdom.

In view of the comparatively long life of drums of this kind it will no doubt be a considerable time before the standard can be fully operative. It is hoped, however that all concerned will collaborate by changing over gradually to the standard drums. The range includes four different flange diameters, each with two traverse dimensions. The standard gives full details of dimensions and specifies the essential requirements for materials, construction, reeling, wrapping, labelling and marking. It also introduces a system of reference numbers for the identification of the drums. A new

feature is the specification of a peg hole in each drum to take a braking device.

BROAD FLANGE BEAMS, HEAVY FLANGE T-BARS LONG-LEGGED T-BARS (B.S.2566 : 1955) PRICE 2s. 6d. B.S.2566 : 1955 extends the range of standard sections covered by B.S.4, "Channels and Beams"; B.S.4A, "Equal Angles, Unequal Angles and T-Bars"; and B.S.6, "Bulb Angles and Bulb Plates." The new sections have been standardised bearing in mind that up to now the range of standard sections did not cover fully the requirements for welded construction. Consideration was given to a wide range of special sections which from time to time had been put forward as incorporating factors which would facilitate their being welded. It was found that the most useful and economical sections were those covered in this new British Standard. Other proposed sections were rejected as either having no real advantage or being of such a shape that they could not be rolled without excessive difficulty; in the latter class are specially ribbed sections and special sections with square edges.

Copies of these standards may be obtained from the British Standards Institution, Sales Branch. 2, Park Street, London, W.1.

Cast Steel Roll Production

Improved Melting Facilities for R. B. Tennent, Ltd.

A REFERENCE in the 1864 edition of Miller's "Rise and Fall of Coatbridge" states that Mr. Robert Tennent, the enterprising lessee of the foundry situated at the bottom of Buchanan Street, had recently expended upwards of £1,000 on extensions and rebuilding, to enable him to meet the demand for heavier castings for machinery and goods of like description. In those days the firm was only seven years old, but today, when it is approaching its centenary, and is a leading member of the British Rollmaker's Corporation, R. B. Tennent, Ltd., is still making provision to meet the growing needs of industry.

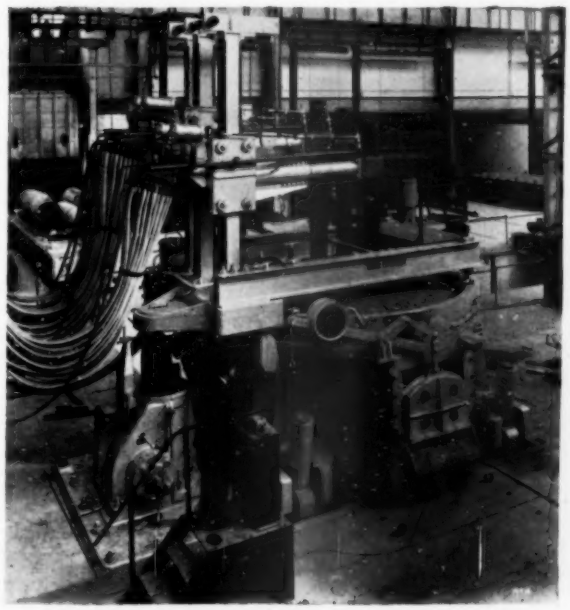
Early Progress

In the early days, the main products were hammer faces, anvils, and machinery castings for local ironworks, heater pipes with bends, pit rails, chairs, and miscellaneous castings for mines and blast furnace plants. In 1870 the works were transferred to the present site at Whifflet, where a new foundry and machine shop had been built. Equipped with two air furnaces, in addition to cupolas, castings of much greater weight were possible, and this enabled the company to meet the needs of the new steel works which began to spring up in the area in the early 1870's.

Beginning about the same time with rolls for the local ironworks, roll making soon became of increasing concern to Tennent's and by 1890 formed an important part of the total output. Up to this time, ingot moulds, the other major item which required continuous replacement in the steel plants, were also produced, but their manufacture was then practically abandoned in favour of concentration on roll making.

In 1879, Mr. R. B. Tennent visited Germany and purchased from Gontermann-Peipers a patented method of chilled roll moulding, and shortly afterwards began experiments in making large chilled rolls for the rolling of plates. Although success did not come for many years, chilled plate rolls proved to be the foundation on which Tennents' were established as roll makers, and in 1889 an additional foundry was built for their production.

The next major development was the entry into the steel casting field in the first decade of the present century. Progress followed much the same lines as in the case of iron, general castings forming the bulk of the output in the early days, with few rolls, the proportions changing gradually until today the production of rolls forms over 95% of the steel output. Further extensions



An overhead view of the new furnace showing the arrangement of the electrode gear.

about this period completed a programme which satisfied requirements of production for the next 25 years.

Continued Expansion

In 1934 a programme of replacement and expansion was begun which continued until interrupted by war demands in 1940. During those years the old lathes, which were operated manually, were replaced by modern precision machines with push button control; new and improved types of machine tool were added to meet the extreme accuracy limits demanded of the electrically driven mill, in which a tolerance of plus or minus one or two thousandths of an inch is not unusual. The crane carrying capacity was also increased and the casting plant was converted from iron to steel. In 1935 the manufacture of Adamite began under licence from the Mackintosh-Hemphill Co. of Pittsburgh, U.S.A.

In 1948 a further programme of development and expansion was undertaken to meet the ever increasing

Furnace tilted slightly backward to facilitate slag removal.

demand for rolls throughout the world. Accordingly, the erection of new buildings for research, heat treatment, machining, moulding and casting was begun. The first phase called for extensions of the present heat treatment and machining facilities, and by 1950 two additional buildings had been completed. The installation of oil fired heat treatment furnaces, heavy duty lathes and ancillary equipment was then undertaken, the majority of the tools being of Craven manufacture and incorporating the most up-to-date British designs in roll machining equipment.

The second stage of this expansion programme was started in 1950 and completed this year. This extension consisted of an additional foundry connected with the existing foundry by an electric transfer car and complete with sand handling, moulding, drying, melting, casting and annealing equipment. Of special note is the melting unit, a Birlec 12-ton Lectromelt electric arc furnace, which was installed in 1954 and is now in full operation.

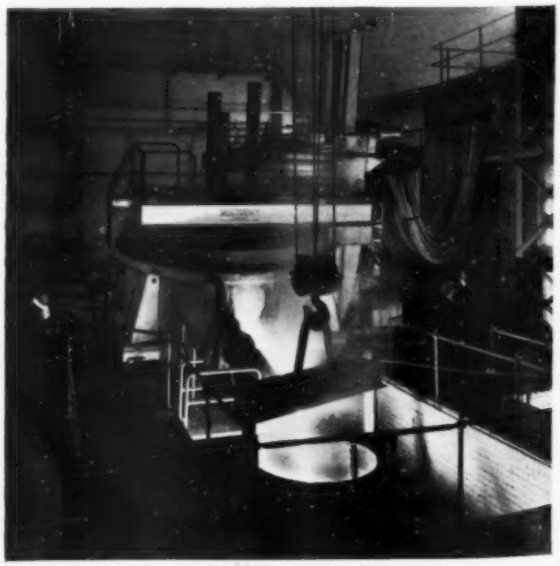
New Melting Furnace

The furnace has a diameter of 12 ft. and is constructed of heavy gauge steel plates lined with suitable refractory material. A top stiffening bezel ring, which is water cooled, is provided to prevent distortion under heat. For slagging, oxygen lancing, fettling and other operations there is a refractory-lined door let into the side. The pouring spout, which is also lined with refractory material, is attached to reinforcements on the shell. The roof refractories are supported on a water-cooled channel section ring which is suspended at four points on two structural steel beams, an arrangement which facilitates removal and replacement and obviates any trouble in aligning the electrode ports and electrodes. The roof structure has an eye attachment in which a vertical hydraulic ram engages to lift the roof clear of the furnace for top charging purposes. When the roof is raised clear of the furnace body it is swung round through an angle of nearly 75° to expose the hearth. Loading can then be effected by lowering a drop bottom bucket into the shell. These operations are controlled by interlocked mechanism to ensure that they take place in the correct sequence. Tilting is effected by a pair of rams, the oil pressure for which, and for the roof raising mechanism also, is generated in a self-contained electrically-driven plant.

Power for operating the furnace is obtained from the public mains on the three-phase system at 11 kV through a metal-clad switch supplied by A. Reyrolle & Co., Ltd. This switch controls the supply to a 4,000 kVA transformer of Electric Construction Co., Ltd., manufacture. The three 10 in. diameter electrodes are secured in water-cooled copper clamps and project vertically through the furnace roof. The clamps, which are operated by remotely controlled pneumatic mechanism, are mounted on the ends of horizontal arms which also carry the electrical and water connections. The horizontal arms are connected to vertical masts by cross-heads which in turn are suspended from flexible steel cables connected to individual winches. These winches are installed below the furnace floor and are provided with drums over which the cables pass to terminate in counterweights. Each winch is driven through gearing from a direct-current motor, the field of which is permanently excited at constant voltage and the speed and direction of which depend on the magnitude and polarity of the output voltage of a B.T.H. Amplidyne unit. All the controls and metering equipment for the furnace are situated on a board on the wall of the transformer sub-station.

Capacity Working

R. B. Tennent, Ltd., have been working to capacity from 1938 to the present day, and are producing iron and steel rolls of all sizes and types to meet the requirements of the steel mills at home and abroad. The range of rolls manufactured is extensive and includes the large back-up rolls employed by the continuous strip mills of Great Britain, France, Italy, South Africa and Australia. Considerable quantities of their other type rolls are exported also to these countries, and to countries such as Southern Rhodesia, Canada, India, Turkey, Spain, Holland, etc.



Tapping the furnace

Drilling Tests on a Titanium Alloy

Results of a PERA Investigation

IN view of the growing interest in the use of titanium and its alloys in engineering structures, particularly in the aeronautical field, the Production Engineering Research Association of Great Britain has carried out an investigation into the factors influencing the drilling of the titanium alloy Ti 150A, which contains some 2½% chromium, in order to determine the effect of point shape, helix angle, cutting speed, feed rate and cutting fluid on the performance of high speed steel drills. The information presented here is based on the Association's report, which has hitherto been confidential to members.

Material and Equipment

Test Specimens

The chemical composition of the 2-in. diameter Ti 150A bars used for the tests was

	C%	Fe%	N%	Cr%	Ti
Maker's Specification	0·047	—	0·10	2·58	Remainder
Analysis	0·050	1·48	0·10	2·75	Remainder

Test specimens ¾ in. long were parted off and hardness readings were taken on specimens from each end and the centre section of each bar. The values shown in Table I are the Vickers diamond hardness readings (30 kg. load) taken at ⅛ in. intervals across the diameter of each specimen.

Drills

Letter *P* drills (0·323 in. diameter), having 10°, 25° and 42° helix angles (see Fig. 1 for drill nomenclature), were used for the tests, selection from a batch of 18–4–1 high speed steel drills being on the basis of similarity in hardness and geometrical accuracy. The size of drill was selected to provide a suitable core hole diameter for a subsequent tapping investigation.

The test drills were ground to the specified angles on a conventional drill point grinding machine. The point angle was controlled to within ±1°; the relief angle to within ± ½°; and a tolerance of 0·001 in. was permitted for the relative lip height. These features were all checked on the PERA drill point inspection instrument seen in Fig. 2.

PERA Drill Point Inspection Instrument

For measuring the relief angle (see Fig.3), the drill, mounted in a vee block, is positioned with the drill axis perpendicular to a fixed cross-wire in the eyepiece of the microscope. The eyepiece, which can be rotated, is set at zero on the 360° protractor, and the drill is rotated in the vee block until the image of the drill outer corner coincides with the centre mark on the cross-wire. The eyepiece is then rotated to align the cross-wire with the image of the intersection of the drill land and flank, and the relief angle at the outer corner is read directly from the protractor scale.

The point angle is measured by viewing the cutting edges through the microscope and reading the angle on the protractor.

The relative lip height (see Fig. 1) is measured by moving an adjustable cross-wire in the microscope eyepiece into coincidence with the drill outer corner; a reading is then taken on the calibrated dial which controls the position of this adjustable cross-wire. The drill is next rotated through 180°, axial movement being prevented by a suitable stop at the shank end of the drill, and the adjustable cross-wire again moved to coincide with the image of the drill outer corner. The difference between the readings on the calibrated

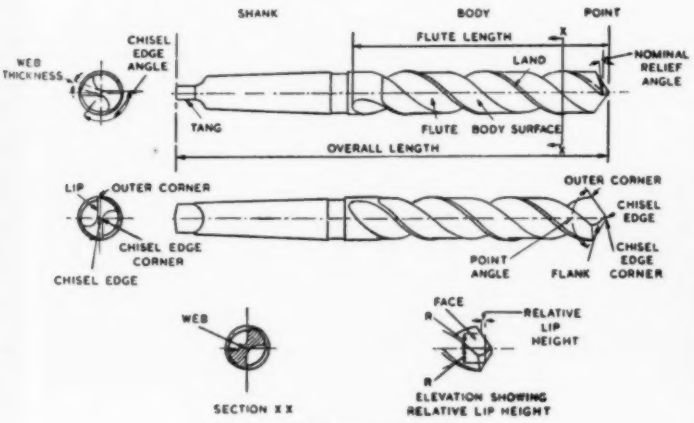


Fig. 1.—Drill nomenclature.

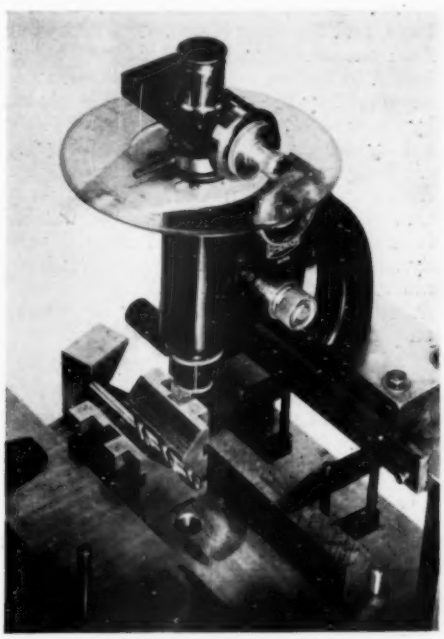


Fig. 2.—FERA drill point inspection instrument.

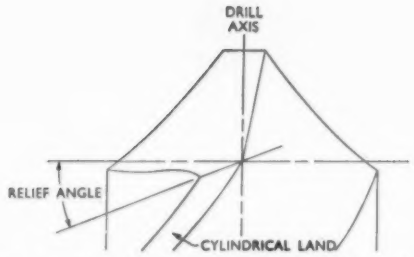


Fig. 3.—Sketch of drill showing relief angle.

dial at the two settings is the relative lip height of the drill.

Portal Frame Drilling Machine

The drillings tests were carried out on the portal frame drilling machine seen in Fig 4, which consists of a 30-in. all-geared drilling machine head mounted on a special frame. The machine is driven by a 7½ h.p. motor through vee belts, and eighteen speeds, from 30 to 1,500 r.p.m., and eighteen feeds, in the range 0·0006–0·048 in./rev., are provided.

Cutting Fluid

The cutting fluid tank has a sump from which the cutting fluid is drawn by a centrifugal pump and delivered through an annular distributor having eight nozzles (Fig. 5). Three cutting fluids were used: (*a*) soluble oil of specification similar to that given for oil No. 1 in the PERA report on "Tests on Soluble Cutting Oils"*; (*b*) mineral oil to SAE 20; and (*c*) sulphurised neat oil to SAE 10.

Torque and Thrust Dynamometer

The torque and thrust dynamometer used is shown in Fig. 6. It consists of three main parts: the body, the table, and the inner sleeve. The second and third parts form one assembly, the inner sleeve being spigoted and bolted to the underside of the table. This assembly is supported by the thrust pin, and is located on the body by roller races. It is, therefore, free to rotate and float axially within the limits imposed by two stiff steel diaphragms mounted on knife edge supports. The diaphragms are of such proportions that their deflection under maximum load is only 0·002 in. The test specimen is clamped in the special fixture attached to the dynamometer table, and the drilling torque and thrust are transmitted to different diaphragms, the resultant deflections being electronically amplified and recorded on pen recorders.

Testing Procedure

Through holes ¾ in. long were drilled except where drill failure occurred before this depth was reached. The criterion of drill performance was drill life, expressed as the total depth of hole drilled before the outer corners of the drill failed and regrinding was required. This failure was accompanied by continuous screeching and a sudden increase in drilling thrust. Prior to the main series of tests, it was necessary to establish a cutting speed, feed rate and cutting fluid which would give reasonably consistent drill life during the main series of point angle and relief angle tests.

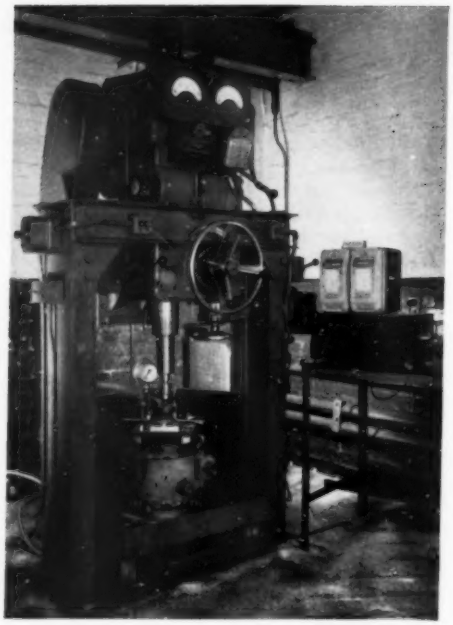


Fig. 4.—Portal frame drilling machine with dynamometer and pen recording unit.

Point Angle and Relief Angle Tests

During the point angle and relief angle tests, the cutting speed and feed rate were selected on the basis of preliminary tests and controlled at 64 ft./min. and 0·0014 in./rev., respectively. Tests were carried out in a randomised order, using point angles of 105°, 115°, 125° and 135°, and relief angles of 7°, 10°, 13° and 16°. After completion of these tests it was found necessary to carry out four additional tests using a 95° point angle. The cutting fluid was one part mineral oil, five parts soluble oil, and eighteen parts water.

Cutting Speed and Feed Rate Tests

The drill point used for the cutting speed and feed rate tests was based on the most satisfactory results obtained during the point angle and relief angle tests. Tests were carried out in a randomised order using cutting speeds of 64, 71, 80 and 91 ft./min. and feed rates of 0·0014, 0·0029, 0·0059 and 0·0100 in./rev. The cutting fluid used was one part mineral oil, five parts soluble oil and eighteen parts water.

* See METALLURGIA, **48**, 233-240.

TABLE I.—HARDNESS READINGS TAKEN ON THE FACE OF THE TEST SPECIMENS AT ⅛ in. INTERVALS ACROSS THE DIAMETER

Specimen No.	Hardness Reading (D.P.N. 30 Kg. Load)															
4	393	404	391	391	383	389	385	364	396	402	393	391	377	389	381	387
59	385	368	375	362	366	357	355	344	353	351	366	357	360	370	357	385
98	362	366	379	379	373	377	368	360	371	375	375	381	375	370	373	391

TABLE II.—EFFECT OF POINT ANGLE ON DRILL LIFE, TORQUE AND THRUST (Cutting Speed: 64 ft./min.; Feed Rate: 0·0014 in./rev.; Helix Angle 25°; Cutting Fluid: Soluble oil plus mineral oil at 1 : 3 dilution).

Point Angle	Length of Hole Drilled (in.)	Torque (lb. in.)	Thrust (lb.)
95°	1·1		
105°	27·8	47·25	483
115°	17·3	54·75	490
125°	12·8	59·5	547
135°	4·7	67·8	550

Each result is the average of four tests

TABLE III.—EFFECT OF RELIEF ANGLE ON DRILL LIFE, TORQUE AND THRUST (conditions as for Table II).

Relief Angle	Length of Hole Drilled (in.)	Torque (lb. in.)	Thrust (lb.)
7°	10·5	59·4	535
10°	22·5	58	450
13°	16·5	53	537
16°	12·5	59	573

Each result is the average of four tests

TABLE IV.—EFFECT OF CUTTING SPEED ON DRILL LIFE, TORQUE AND THRUST (Point Angle: 105°; Relief Angle: 10°; Helix Angle: 25°; Cutting Fluid: Soluble oil plus mineral oil at 1 : 3 dilution).

Cutting Speed (ft./min.)	Length of Hole Drilled (in.)	Torque (lb. in.)	Thrust (lb.)
64	10·5	40·75	635
71	—	52·75	700
80	0·85	55·25	677
91	0·3	43·25	727

Each result is the average of four tests

TABLE V.—EFFECT OF FEED RATE ON DRILL LIFE, TORQUE AND THRUST (same condition as for Table IV).

Feed Rate (in./rev.)	Length of Hole Drilled (in.)	Torque (lb. in.)	Thrust (lb.)
0·0014	12·25	36·7	480
0·0029	0·85	54	725
0·0059	0·2	52·7	812
0·0100	0·2	50·4	720

Each result is the average of four tests

Cutting Fluid Tests

The efficiency of various cutting fluids was checked by tests carried out using the cutting speed, feed rate, and drill point shape found to be most satisfactory during the earlier tests. Two tests were carried out in a randomised order when cutting dry and when using the following fluids.

Cutting Fluid	*Dilution*
Soluble oil (5 parts); mineral oil (1 part). (Also referred to as soluble oil plus mineral oil at 1 : 3 dilution).	1 : 3
Soluble oil (5 parts); mineral oil (1 part)	1 : 5
Soluble oil	1 : 3
Soluble oil	1 : 5
Soluble oil	1 : 10
Soluble oil	1 : 20
Sulphurised neat oil	—

Helix Angle Tests

Helix angle tests were carried out using the cutting speed, feed rate, drill point shape, and cutting fluid found most satisfactory during the earlier tests. Three tests were carried out in randomised order for each of three helix angles, namely, 10°, 25° and 42°.

Results

In setting out the results of the point angle, relief angle, cutting speed and feed rate tests, the individual experimental values have been omitted to avoid giving a false impression of the magnitude of the experimental error in the test series. In the point angle and relief angle tests, and in the cutting speed and feed rate tests, two conditions were varied simultaneously, so that, when considering the results obtained at a given point angle, variation in drill life can be attributed principally to the effect of varying relief angle.

Point Angle and Relief Angle Tests

Tables II and III show the effect of point angle and relief angle on drill life, torque and thrust. The best drill life was obtained using a point angle of 105° and a relief angle of 10°. A point angle of 105° also resulted in the lowest drilling torque and thrust: due to rapid drill failure at 95° point angle, it was not possible to record torque and thrust. From Table III it can also be seen that the average thrust when using a 10° relief angle was about 80 lb. less than the lowest average thrust for the other three relief angles. The lowest average torque was recorded when using a 13° relief angle, the value being 5 lb. less than that recorded when using a 10° relief angle.

Cutting Speed and Feed Rate Tests

Tables IV and V show the drill life, torque and thrust obtained at various cutting speeds and feed rates. Superior drill life was obtained using a cutting speed of 64 ft./min. and a feed rate of 0·0014 in./rev. The average drilling torque and thrust were lowest at the above cutting conditions.

Fig. 5.—Ring type cutting fluid distributor.

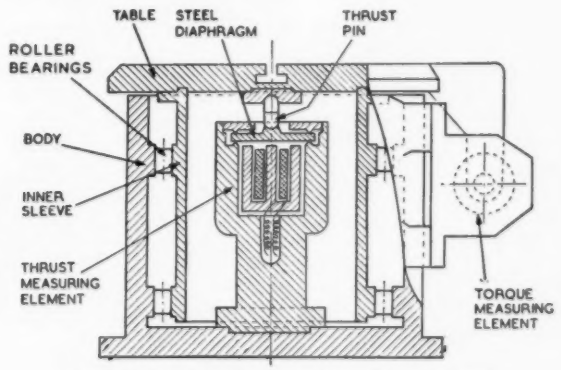


Fig. 6.—Sectioned view of torque and thrust dynamometer.

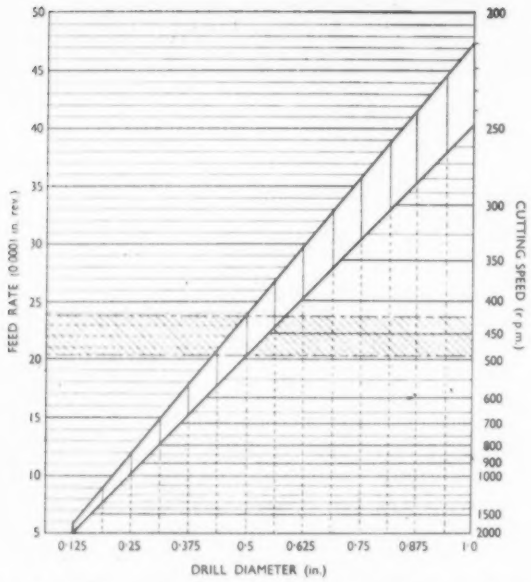


Fig. 7.—Guide to recommended cutting speeds and feed rates for drill sizes $\frac{1}{8}$ in. to 1 in. diameter. For example, the cross-hatched section shows these values for a $\frac{1}{2}$ in. diameter drill.

Cutting Fluid Tests

Table VI shows the order of performance of the cutting fluids, determined by the average drill life, torque and thrust when using the various fluids. Superior drill life was obtained when using one part mineral plus five parts soluble oil diluted with eighteen parts water. The lowest torque was recorded when using the cutting fluid described above, and the lowest thrust was obtained with a sulphurised neat oil.

Helix Angle Tests

The effect of helix angle is shown in Table VII. Superior drill life was obtained using 25° helix angle, and from the average drilling torque and thrust recorded during the tests, it can be seen that the lowest values are recorded when using the 25° helix angle drills.

General

It is probable that drill life would have been increased when using lower cutting speed and feed rates than those found to be most suitable during this series of tests. It was not considered, however, that any useful purpose would have been served by using cutting speeds and feed rates which would have resulted in a penetration rate of less than 1 in. min. When drilling titanium, the most severe condition occurs as the drill breaks through, and since through holes were drilled in this series of tests, longer drill life may be expected when drilling blind holes.

Recommendations

For the drilling of titanium alloy Ti 150A the following recommendations are made :

(1) The point angle should be 105°.
(2) The relief angle should be 10°.
(3) Drills with helix angles of the order of 25° should be used.
(4) The cutting speed should be approximately 60 ft./min.
(5) A penetration rate of 1 in./min. should be used.

TABLE VI.—EFFECT OF CUTTING FLUID ON DRILL LIFE, TORQUE AND THRUST (Point Angle : 105° ; Relief Angle : 10° ; Cutting Speed : 64 ft./min. Feed Rate : 0·0014 in./rev. ; Helix Angle : 25°).

Cutting Fluid	Length of Hole Drilled (in.)	Torque (lb. in.)	Thrust (lb.)
Soluble oil plus mineral oil at 1 : 3 dilution	38·4	31·7	410
Soluble oil plus mineral oil at 1 : 5 dilution	20·8	55·5	530
Soluble oil 1 : 3 dilution	20·6	42·0	465
Sulphurised neat oil	3·6	43·5	335
Soluble oil 1 : 5 dilution	1·6	43·5	510
Soluble oil 1 : 10 dilution	1·3	37·5	470
Soluble oil 1 : 20 dilution	0·8	47	540
Dry	0·5	68·5	710

Each result is the average of two tests

TABLE VII.—EFFECT OF HELIX ANGLE ON DRILL LIFE, TORQUE AND THRUST (Point Angle : 105° ; Relief Angle : 10° ; Cutting Speed : 64 ft./min. ; Feed Rate : 0·0014 in./rev. ; Cutting Fluid : Soluble oil plus mineral oil 1 : 3 dilution).

Helix Angle	Length of Hole Drilled (in.)	Torque (lb. in.)	Thrust (lb.)
10°	5·5	52·5	765
25°	37·25	33·5	495
42°	1·0	57·5	595

Each result is the average of three tests

(6) The cutting fluid used should consist of one part mineral oil SAE 20, five parts soluble oil, and eighteen parts water. The mineral oil should be mixed with the soluble oil and then added to the type water.
(7) A copious supply of cutting fluid should be applied using a cutting fluid distributor of the type shown in Fig. 5.

These recommendations are based on tests in which 0·323 in. diameter holes were drilled, but it is suggested that they can be used as a guide to other drill sizes in the range $\frac{1}{8}$ in. to 1 in. diameter (see Fig. 7).

Acknowledgments

This investigation was sponsored by the Ministry of Supply and acknowledgment is made to them for granting permission to publish their work. The members of PERA staff principally concerned were R. J. Lowrie and M. Walker.

Appendix

In order to determine if titanium alloy Ti 150A work hardened during machining, Vickers diamond hardness and Tukon micro-hardness readings were taken on the walls of the holes where drill failure and rubbing had occurred, and also where the drilling operation had been satisfactory. Vickers hardness readings taken under these conditions showed very little variation : the average hardness for both types of drilled surface was 440 D.P.N. (1 kg. load)—an increase of 70 above the average hardness reading taken on the surface of a specimen sectioned at 90° to the parted-off surface.

Microscopic examination of a section through the wall of " good " and " bad " holes, showed that, although the drill failure and rubbing is conducive to work hardening, the grain structure of the material was virtually unchanged, although there was some distortion shown by the surface layer. Microhardness readings taken on these two specimens gave no indication of work hardening of the distorted layer.

In an attempt to obtain some indication of the relative machining characteristics of titanium alloy Ti 150A, drilling torque and thrust were measured when drilling sub-critically annealed En 30B nickel-chromium-molybdenum steel. Although En 30B is considered to be difficult to machine, the torque and thrust were 50% higher when machining Ti 150A under similar conditions.

Electrical Plant for the Metal Industries

Progress in 1954 Reported

THE electrical industry continues to play a major part in the provision of equipment for the metallurgical and metal-using industries. Electrical drives for rolling mills—whether as new construction or for the modernisation of existing mills—undoubtedly constitutes one of the outstanding applications of electricity in this field, but a considerable volume of business concerns the smaller motors, switchgear, and, more recently, electronic control equipment. The following information, based on surveys of the activities of a number of the large electrical engineering concerns in 1954, will give some idea of the extent to which metal working depends on electricity. The review is not exhaustive, and such items as electric furnaces for heat treatment are no more than mentioned in view of the review of developments in that field which we hope to publish later in the year.

British Thomson-Houston Co., Ltd.

Rolling Mills

The most interesting B.T.H. rolling mill drive to go into operation during the year has been that for the new "Plug" mill at Stewarts & Lloyds, Ltd., Corby, which produces seamless steel tubes. The main drives comprise a 1,500-h.p., 500-r.p.m., 11,000-volt slipring induction motor driving the piercer, a 1,000-h.p., 300-r.p.m., 11,000-volt induction motor driving the plug mill, and two 350-h.p., 500-r.p.m., 3,300-volt motors driving reelers. A further 350-h.p. motor drives a sizing mill. The 1,500-h.p. and 1,000-h.p. motors are arranged for closed air circuit ventilation with water cooling. In addition there is a large number of auxiliary drive motors, several large contactor control panels, and many special control stations. The main part of the electrical equipment was supplied to the order of The Head Wrightson Machine Co., Ltd.

Also put into operation in 1954 was the drive for an extension to the bar mill at Steel Peech & Tozer, Ltd., comprising two 300-h.p., 300/600-r.p.m., D.C. motors supplied from two pumpless steel tank mercury arc rectifiers. Cold strip rolling mill equipment installed at Guest Keen & Nettlefolds (South Wales), Ltd., comprised a 350-h.p., 300/800-r.p.m., D.C. motor, a 250-kW. motor-generator set, and a 60-h.p. tension reel motor with automatic strip tension control by means of amplidynes.

The year has also seen the completion and despatch to Australia of two very large rolling mill equipments. One of these is the drive for a wide hot strip finishing mill for the Australian Iron & Steel Co., Port Kembla, comprising five 4,000-h.p. and one 3,500-h.p. D.C. motors, and three 6,000-kW. motor-generator sets. The other is the drive for a 4-stand cold tandem strip mill for Lysaghts Works Proprietary Co., Ltd., Port Kembla comprising one 2,000-h.p., three 4,000-h.p., and one 1,000-h.p. D.C. motors, and one 6,000-kW. motor-generator set. A 650-h.p., 750-r.p.m., 2,200-volt slipring induction motor was also despatched to drive a bar rolling mill in Rhodesia.

Courtesy of The British Thomson-Houston Co., Ltd.

4,000 h.p., 145/326 r.p.m., 750 volts D.C. motor, one of six for driving a hot strip finishing mill at Australian Iron and Steel, Ltd., Port Kembla.

The 4-high 32-in. wide foil mill referred to in our last review has been commissioned, as also have the nine hot-dip tinning lines at the Trostre Works of the Steel Company of Wales, Ltd.

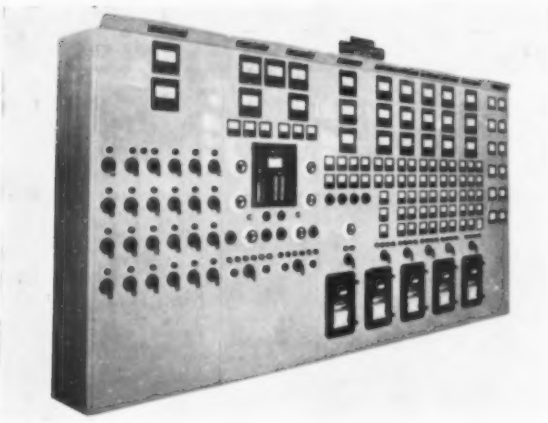
Several large orders for rolling mill plant have been placed with B.T.H. during the year. First in point of size is that for electrical equipment for the Dorman Long (Steel), Ltd., new broad flange beam mill at Lackenby Works. This order includes two 2,700-h.p. twin drive reversing equipments for edger stands and two 8,600-kW. and one 6,450-kW. flywheel motor-generator sets.

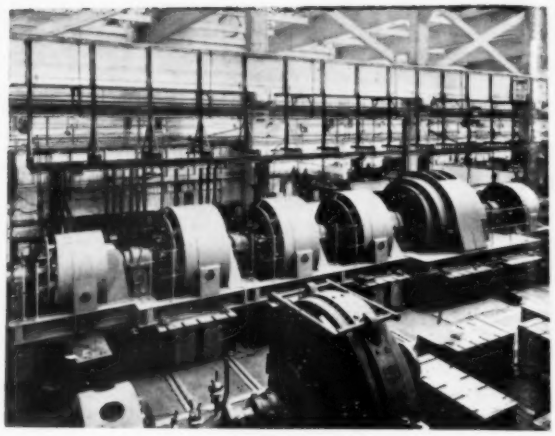
From Shepcote Lane Rolling Mills, Ltd., Sheffield, an order has been received for a 2,800-h.p., 65/130-r.p.m. and a 200-h.p., 300/900-r.p.m. reversing D.C. motor, and a 4,800-kW. synchronous motor-generator set for a stainless steel strip mill; and a 1,500-h.p., 750-r.p.m., 5,500-volt slipring induction motor for driving a merchant mill is being built to the order of the Shelton Iron, Steel & Coal Co., Ltd.

An order has been received via Davy & United Engineering Co., Ltd., for electrical equipment for a high-speed electrolytic cleaning line, to be installed by Richard Thomas & Baldwins, Ltd., Ebbw Vale. It covers twenty-five A.C. motors ranging from 1½ h.p. to 100 h.p., one 5-unit motor-generator set supplying twenty-nine Ward-Leonard controlled motors ranging from 5 h.p. to 150 h.p., together with full control equipment. The larger D.C. motors are of the totally enclosed closed air-circuit pattern, having air ducts incorporated in the baseplates. Magnestats will be used for the tension control on the coiler and uncoiler reels.

Arc Furnace Equipment

Recent years have shown a marked increase in electric steel making capacity, and B.T.H. have made an important contribution to this expanding business. An





Courtesy of The British Thomson-Houston Co., Ltd.

Supervisory control panel (left) and 6,000 kW motor-generator set for tandem cold strip rolling mill at Lysaght's Works Pty., Ltd., Port Kembla.

efficient electrode position regulator plays an important part in maintaining the necessary close control of an arc furnace, and the B.T.H. amplidyne control scheme has been specially developed for high sensitivity, speed of response, speed of correction proportional to error, and low maintenance.

Several equipments have been commissioned this year, but the most striking example is that for the 60-ton Birlec furnace at the Stocksbridge Works of Samuel Fox & Co., Ltd. In addition to control gear and amplidyne motor-generator sets for automatic control of electrodes, a special feature was the incorporation of a further motor-generator set and changeover switches, enabling a spare set to be switched in for servicing or in the event of failure.

The outsize 20-in. electrodes, driven through gears by 15-h.p. Type MDX mill motors, were uncounterbalanced, and special biasing circuits were included to simulate electrically the balancing torque, which in small-size furnaces is normally provided by electrode assembly counterweights.

The control cubicle of B.T.H. new QG-type pattern, was designed for ease of servicing, each electrode panel being readily removable.

Earlier this year B.T.H. supplied electrical equipment for an interesting electro-hydraulic scheme for control and operation of the electrodes of two 7,500-kVA ferro-silicon smelting furnaces destined for South Africa. Operation of the electrode platform assemblies is performed hydraulically, whilst control is provided by B.T.H. equipment comprising 3-unit amplidyne motor-generator sets and associated gear supplying controlling power to 10-h.p. Type DY pump motors.

More than a dozen electrode control sets are in process of manufacture, four of them destined for Birlec furnaces to be installed in India. Furnace transformer orders include three at 1,500 kVA., 6,600/215–85 volts and two at 3,000 kVA., 6,600/230–85 volts—all for India—and one at 1,200 kVA., 11,000/220–103 volts and one at 3,000 kVA., 11,000/220–83 volts for A.G.E. Co., for Commonwealth Steel Co., Australia.

High-Frequency Equipment

Perhaps the most interesting order commissioned during the past 12 months in this field was for two 600-kW., 1-kc./s. substation equipments for Birlec induction furnaces for Sheepbridge Steel Castings, Ltd., at Sutton-in-Ashfield. These equipments, concerned in the production of alloy steels, comprise 11-kV., 1,000-h.p. synchronous motors driving 600-kW., 1-kc./s., 0·9 power factor, inductor alternators, with voltage control by Type FV 29 thyratron voltage regulators and excitation by overhung exciters. In view of the large weight of the inductor alternator rotors, pressure-forced lubrication is provided and inter-locked so that the equipment cannot be started unless the auxiliary pump motors are operating. The main motor starting equipment, of the reactor type, includes a 150-MVA., Class QA circuit-breaker with thermal overload and instantaneous fault protection.

Further orders for 1, 3 and 10 kc./s. induction heating and melting equipments have been received for home and export during the year, many being for the Ministry of Supply.

Industrial Electronics

Magnetic Amplifiers.—Development of magnestats (magnetic amplifiers) for industrial and service applications has proceeded throughout the year. The development of the 3-kW. D.C. output unit mentioned last year has been completed, and will be used on one of the Ward-Leonard controls which are being supplied for the Velindre Works of the Steel Company of Wales, Ltd.

Communications.—More installations have been made of the Clearcall System of sound amplification. Audio-frequency systems have been installed at many industrial plants, including those at the Corby Works of Stewarts & Lloyds, Ltd., and at the Steel Company of Wales, Ltd.

The amplitude-modulated carrier system for communication over supply mains between fixed and moving locations has been further developed, and installations have been made in a number of factories for communication between cranes and fixed ground positions. A successful demonstration of its use for communication between the controller of shunting operations and the drivers of diesel shunting locomotives has also been given.

Emotrol Units.—During the year, three Emotrol (electronic motor control) units have been supplied to the Telegraph Construction and Maintenance Co., Ltd., for the control of machines engaged in the manufacture

of the new transatlantic telephone cable. Three units have also been supplied to the Glacier Metal Co., Ltd., for the control of geared motor units running at 60,000 r.p.m. for high-speed bearing research.

Photo-electric Equipment.—Amongst the equipment supplied to the steel industry is a photo-electric shear and twist pipe control for a French rod mill, similar to a B.T.H. installation in this country.

Mercury Arc Rectifiers

For steelworks auxiliary supplies, four mercury arc rectifier sets have been completed for the Newport, Bilston and Glasgow works of Stewarts and Lloyds, Ltd., and a further three units are in hand for the Cleveland Bridge and Lackenby Works of Dorman Long & Co., Ltd.

English Electric Co., Ltd.

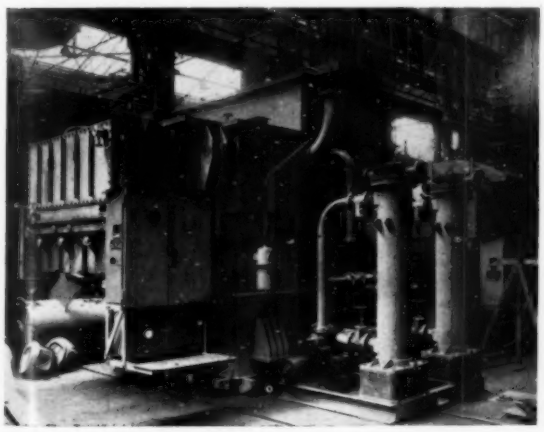
Rolling Mills

During 1954, many orders were received covering electrical plant for installation in steelworks, and several interesting equipments were delivered and put into service. Orders were received for five hot reversing mill main drive equipments for blooming and slabbing purposes, the ratings varying from about 3,000 h.p. in the conventional single armature form, to 8,000 h.p. in the twin-drive form. (Steam engines are being replaced by three of these equipments).

A non-ferrous plant in Canada will contain a complete set of English Electric equipment for various hot and cold rolling mills: the order includes all the necessary distribution switchgear, transformers and fusegear. Other cold strip mill equipments ordered during the year include machines and control gear for the modernisation of an existing cold tandem mill. The additional equipment means that the speed of production will be doubled.

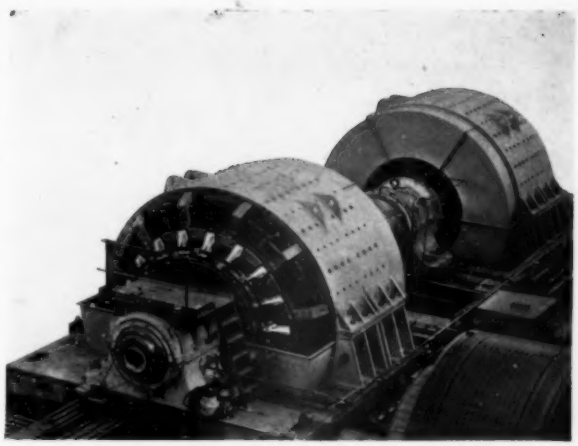
Among the equipments installed during the year is an important blooming mill main drive in Sweden, for rolling special steels. This has an r.m.s. rating of 5,800 h.p. at 52/120 r.p.m. and is the second main drive equipment which English Electric have supplied for this one Swedish works.

An Indian steelworks is now producing billets on a new mill having English Electric equipment. This plant is a little unusual in that the roughing stands have individual



Courtesy of The English Electric Co., Ltd.

15 MVA, 11 kV, 3-phase, arc furnace transformer with on-load tap changing equipment.



Courtesy of The English Electric Co., Ltd.

9,200 h.p. twin drive equipment for a plate mill in Scotland being erected for test.

D.C. motors of 600 h.p. each, while the finishing stands are all driven from a single synchronous motor; this 7,000-h.p., A.C. motor also drives the generator which supplies the roughing stand motors.

Two single-stand cold strip mills are now running in Italy, with English Electric electrical equipment, which includes a 2,500-h.p. motor for one mill and a 1,850-h.p. motor for the other. One mill has tension roll drives, as well as the normal uncoiling and coiling arrangements, so that it may be used for temper rolling as well. Strip speed on both mills is over 1,600 ft./min.

Part of another twin-drive equipment is at present being commissioned. This is a 9,200-h.p. (r.m.s.), 40/80-r.p.m. unit in Scotland, driving a plate mill with rolls 190 in. long.

Other equipment installed during 1954, includes a 7,000-h.p. plate mill main drive, complete with edger, three A.C. drives for roughing stands and Ward-Leonard auxiliary drives, in Australia; Ward-Leonard auxiliary drives for roller tables, etc., on a blooming mill in Norway; and a cutting-up line for heavy strip in Australia.

Rectifiers

Orders received by the Rectifier Substation Department for equipment for electro-chemical duty include a fourth set, rated at 12,000 amps. 325 volts, for the Nchanga Copper Refinery of the Anglo-American Corporation. In addition, the three existing equipments at this refinery are being up-rated from 10,000 amps. to 12,000 amps. Steel works absorbed a considerable number of rectifiers for auxiliary services, and orders include nine 750-kW. units, together with two 500-kW. units, for a new steel works in Spain.

Rectifier equipments put into service during the year included two 4,800-amp. 750-volt units for extending the capacity of an aluminium reduction plant in Norway. The voltage of these equipments is varied by a combination of grid control and on-load tap changing and, in keeping with the majority of electro-chemical loads, full load is maintained continuously day and night.

1954 also saw full service operation of two 3,000-kW. rectifier equipments, in parallel with the motor-generator sets feeding the motors of the Richard Thomas & Baldwin's hot strip mill, and of a 2,500-kW. equipment on similar duty at the hot strip mill of John Summers & Sons, Ltd.

Courtesy of The English Electric Co., Ltd.

25, 5 and 2 kW induction heaters used by Westool, Ltd., in the manufacture of small transformer canisters.

Industrial Electronics

Several large contracts, in which electronic control plays a vital part, have been brought to a successful conclusion, while work commenced on new industrial projects. Those completed include schemes which incorporate automatic systems for improving production methods for a variety of industries, including steel and chemicals, to quote only two examples.

The use of magnetic amplifiers, over a wide range, varying from a few watts to over fifty kilowatts has been undertaken for various schemes, including machine controls, and frequency and voltage regulating systems. Even higher powers are under examination. Although magnetic amplifiers are larger, heavier and slower in action than the orthodox electronic device, their ruggedness has great advantages in certain applications where very high response speeds are not of primary importance.

Further H.F. induction heaters have been developed during the year, backed by an application service designed to ensure their being used with maximum efficiency.

Welding

During 1954, the Welding Equipment Department was very busy on various types of welding machines, and large new multi-operator plants were supplied to many United Kingdom shipyards. New portable welding equipments of advanced design, put into production during the year, have proved popular and substantial orders have been received from overseas. A considerably increased variety of welding electrodes is also now available.

Miscellaneous

An interesting order in the Electrical Plant Department covers the development of two drag line excavator drives, comprising D.C. motors for the hoist, bucket crowd and swing motions. The Ward Leonard principle of operation is used, with automatic acceleration and torque control by means of rotating exciter type amplifiers. Of installations recently commissioned, one covers six 6,000-amp. D.C. generator sets for supplying an arc furnace plant in Birmingham for the large scale production of titanium.

The largest arc furnace transformer built in this country—rated at 15 MVA.—was installed at a Sheffield steelworks during the year. It is the first of its type to be fitted with on-load tap changing equipment which greatly improves the operating efficiency of the furnace and increases its daily output.

During 1954, a very large amount of hydro-electric plant has been put into operation. Much of this has been connected with public supply undertakings, but an installation of importance in the metallurgical world is the 122 MVA. alternator at the Kemano power station of the Aluminum Company of Canada, Ltd., which is part of the Kitimat project.

Orders for diesel-electric locomotives received during the year, included a number of 400 h.p. units for Australian Iron and Steel, Ltd.

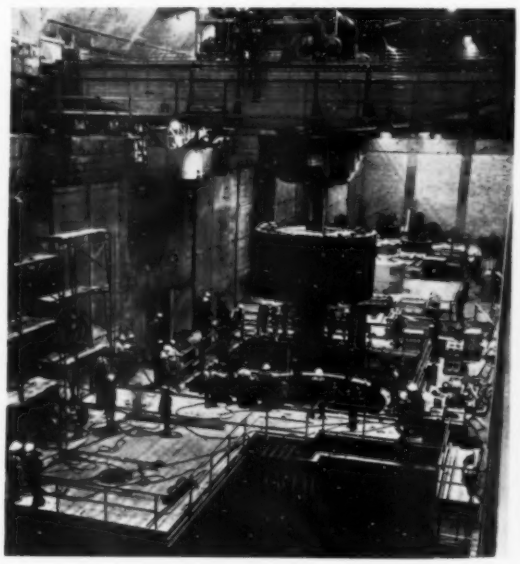
Production of switch and fusegear has continued on a large scale, orders received in this field including a 13-panel switchboard for the Tata Iron & Steel Co. Ltd., Jamshedpur, India.

The General Electric Co., Ltd.

Rolling Mills

Some twenty-five years ago, the G.E.C. installed the electric drive for a 3-stand Krupp mill at the Kynoch Works of Imperial Chemical Industries. This drive has been completely modernised and now embodies the control exciter system installed with marked success at the Steel Company of Wales, at Richard Thomas & Baldwins (Redbourn) and more recently for the skin pass mill at the Whitehead Iron and Steel Co. Ltd.

A contract has been placed by Richard Thomas & Baldwins Ltd. for the conversion of the 3-stand strip mill to a 4-stand mill at their Ebbw Vale Works. The immediate output speed will be 1,500 ft./min., rising to 2,000 ft./min. when stands 1 and 2 are modernised. Two 3,000/4,000-h.p. twin-armature motors will drive stands 3 and 4, and a 750/1,000-h.p. twin-armature machine, the reel drive. A 9,000-h.p. 6-machine motor-generator set, all associated A.C. and D.C. switchgear, control board and mill control cabinets are included.



Courtesy of The English Electric Co., Ltd.

Rotor of 106,000 kVA water turbine driven alternator being lowered into position at Kemano.

Here again the G.E.C. control exciter system will be used.

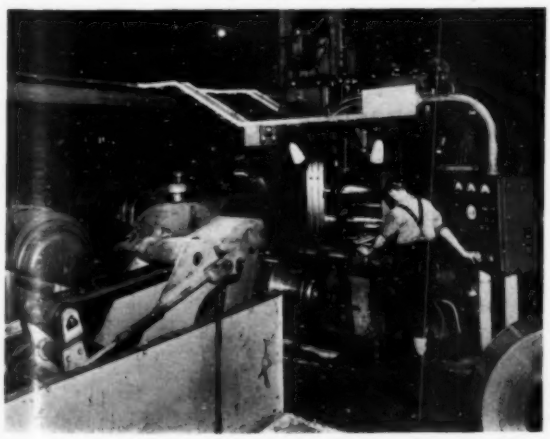
A recent contract from the Steel Company of Wales, Ltd., covers all the electrical equipment for a 78-in. by $\frac{3}{8}$-in. cold cut-up line having maximum outputs of 250 ft./min. of strip up to $\frac{3}{16}$-in. thick or 150 ft./min. for $\frac{3}{8}$-in. strip. The line is designed to cut strip from 20-ton coils into lengths varying from 4 ft. to 36 ft. long and to pile up the cut lengths.

A large amount of equipment is being supplied in connection with the important expansion programme at the Cleveland Works of Dorman, Long & Co., Ltd. A feature of the control scheme is the arrangement whereby full power can be supplied to the shear under emergency conditions so that the mill output is not stopped. This is achieved by interconnecting links which enable full power to be fed from one of the screw-down generators to the shear motors in the event of a shear generator being out of service, the screw-down motors then operating at reduced power. This is performed automatically. The control exciter system is used for both the screwdown and shear drives.

Another order for this steelworks includes all the main drive control gear for a medium section mill for rolling a complete range of medium size structural sections. The mill comprises roughing, intermediate and finishing stands, each driven by a 1,500-h.p. motor, and each supplied from a grid-controlled rectifier equipment. Arrangements are made so that, in an emergency, any two rectifiers feed all three mill motors. In addition, over 100 A.C. mill motors totalling over 7,600 h.p. are on order. For the Lackenby Works all the electrical equipment associated with the auxiliary drives for a broad flange beam mill is being supplied.

Electrical equipment on order for a pickling line in the Shotton Works of John Summers & Sons, Ltd., includes two 550-h.p. and two 50-h.p. D.C. motors together with a 1,400-h.p., 4-machine motor-generator and all associated control gear.

A 500-h.p. mill motor is also being supplied for driving a 10½-in. double-duo steel rolling mill at the works of Kayser Ellison & Co., Ltd. The motor is supplied from a 413-kW. rectifier equipment. The contract also covers four auxiliary A.C. machines and all relevant control gear.



Courtesy of The General Electric Co., Ltd.

24 i . skin pass mill at Whitehead Iron and Steel Co., Ltd.

Courtesy of The General Electric Co., Ltd.

Ore preparation plant in course of erection at the Kapitalna Iron Works, Zenica, Yugoslavia.

For the Australian Iron and Steel Co., Ltd., Port Kembla, a 1,400-h.p. D.C. motor is being supplied to drive an existing mill, and here again control exciters are being used.

Materials Handling and Treating Equipment

Two materials handling plants of particular note have gone into operation during the year. One is the Seraphim project of the Appleby-Frodingham Steel Co., at Scunthorpe, and the other, now partially in operation, is the ore handling and preparation plant supplied to the Kapitalna Ironworks at Zenica, Yugoslavia, to the order of Invest-Import, Belgrade. The plant comprises conveying, primary and secondary crushing and screening of a very comprehensive nature.

The existing ranges of Sherwen feeders and conveyors have been extended and several new standard machines have been added. The new flameproof vibrator, now operating conveyors in collieries below ground, has proved most successful. Two of these new type conveyors are operating at the Seraphim plant beneath the blast furnace coke track hoppers, and feed the incoming coke to the blast furnace conveyors.

A bauxite crushing and washing plant has recently been installed, and is now in operation, in West Africa. Undesirable silica is carried in the fine fraction and the purpose of the plant is to wash the fines from the coarse particles. The electrical equipment of the plant is of standard design and includes both slipring and squirrel cage motors, all totally enclosed, dust and waterproof, and fan-cooled where necessary.

The largest single roll crusher to be built by Fraser and Chalmers Engineering Works was commissioned at a cement plant in Rawang in the Federation of Malaya. The capacity is 120 tons of limestone an hour and reduces 30-in. pieces to a minus 6 in. product. The crusher is of sectionalised cast steel and weighs over 40 tons.

Industrial and Process Heating

The increasing demand for metals for service at high temperatures has called for advances in brazing methods, and a technique has been developed for the copper brazing of stainless steels, and for the brazing of these and other metals using certain proprietary high temperature brazing alloys.

Courtesy of The General Electric Co., Ltd.

Electronically-controlled seam welder for joining thin metal sheets.

An electronically controlled seam welder has been developed for the joining of very thin metal sheets at a speed of 2 ft./min. It will handle steel sheets 10 mils thick, Inconel or nickel 6 mils thick and stainless steel, brass or copper 3 mils thick. It is already in use at Armstrong Siddeley Motors, Ltd., for joining stainless steel sheets 0·004 in. thick covering the insulation material used to absorb jet engine heat on the new Sapphire jet.

Information about an important G.E.C. furnace installation at the Springfields Atomic Factory has recently been released. The installation includes fifty-four 100-kW. cylindrical furnaces and two hundred furnace pots, together with associated control equipment, unloading gear and cranes. The equipment is used for the first of two stages in the conversion of pure ammonium diuranate to metallic uranium.

Modern plant for radiant heating ovens for paint stoving employs two vertical opposing banks of sheathed wire element reflector units. It is well encased and fitted with unheated entrance and exit vestibules to minimise heat losses. Mounted well above head level it makes no demand on floor space. Paint is stoved in about two minutes and some 400 parts an hour can be handled.

Numerous furnaces for straightforward and gaseous-atmosphere heat treatment of metals have also been put into service during the year.

Miscellaneous

Generating Plant.—A number of industrial turbo-generator sets are on order to provide process steam, and include plant for the Steel Company of Wales, Ltd., and the National Physical Laboratory. The G.E.C. is the main contractor for Colvilles £20 million iron and steel project at Motherwell. The contract includes buildings, civil engineering work, boilers, generating plant, turbine-driven blowers, back pressure turbines and cooling towers, together with switch and control gear, transformers, cables and lighting installation.

Mercury Arc Rectifiers.—The 8,000 kW. of rectifier plant brought into service for home industry includes equipment for the Appleby-Frodingham Steel Co., Tube Investments, Ltd., and Stewarts & Lloyds, Ltd., whilst among repeat orders are contracts placed by Appleby-Frodingham, Richard Thomas and Baldwins, Ltd., and the Brightside Foundry & Engineering Co., Ltd.

Electromagnets.—Orders for lifting and separator magnets have been well maintained. In the slab yard of the Steel Company of Wales, two 36-in. magnets are in use for turning 5-ton slabs, and small magnets in cluster form have been supplied for handling coils. The range of lifting magnets has been extended to include deep penetration magnets of 56-in. and 65-in. diameter. These magnets are specially built to meet the demand for greater lifting capacities and for very heavy duties such as are encountered in slag reclamation.

Lead Casting Machine.—A lead casting machine has recently been installed at the Ellesmere Port Works of the Associated Ethyl Co., Ltd. It has a capacity of 10 tons of lead pigs an hour. Eighty-eight moulds form the basis of the machine, each mould having a capacity of 1 cwt. in two 56 lb. pigs. Lead is poured at a temperature of 400/420° C. and the running speed of 2·52 ft./min. facilitates and assists ejection. Drive is by means of a 5-h.p. motor, through two double reduction gears.

Metropolitan-Vickers Electrical Co., Ltd.

Rolling Mills

Rolling mill drives commissioned during the year, include a 4-stand tandem mill for cold rolling steel strip up to 14 in. wide. Individual generators supply each 1,000-h.p. stand motor and the 300-h.p. tension reel motor. There is metadyne control of generator voltage with ohmic drop compensation for each main armature circuit, whilst tension control is by metadyne exciters and magnetic amplifiers.

Drives for seamless tube production in the Midlands, and for rolling aluminium strip in South Wales, have also been commissioned, as has a 400-h.p. edging mill drive, also in South Wales. The last-named has two 200-h.p. 480-volt MDX mill motors connected in parallel and driving through a common gearbox. A preset speed control is provided by a servo-operated motor-driven rheostat controlling the mill motor shunt fields. Ventilation is by means of a self-contained recirculating system incorporating water coolers.

Three equipments for three-stand tandem wire flattening mills for important Government work employ stand drives of 20-h.p. 750/1,500 r.p.m. supplied from a mercury arc rectifier equipment with motor-operated phase shifter control. Metadyne tension control is used on both pay-off and coiling ends, the pay-off motor being 1-h.p., 360/940-r.p.m. and the coiler motor 2-h.p., 360/540-r.p.m.; the coiler is automatically traversed when coiling by a 1-h.p. motor under the control of a metadyne.

Equipment for modifying an 860-h.p. aluminium mill drive is in course of erection in the Midlands, and a large twin-drive for a blooming mill for the North-east Coast is now well advanced. The main motors, each rated at 2,500 h.p., 40/90 r.p.m., and their associated motor generator set will be metadyne-controlled in order to provide fast acceleration and reversal of the mill, together with provision for peak load limitation and load balance between the top and bottom roll motors.

Three large mill drives ordered for the same area cover a 40 in. roughing mill, a 53 in. beam roughing mill, and a 53 in. beam finishing mill. The beam mill will produce parallel broad-flange beams ranging from 36 in. × 1½ in. down to 6 in. × 4 in. Each mill has a double-armature main motor of 8,000 h.p., ±0/65/160 r.p.m., the beam mills having also a twin drive of 1,350-h.p., ±125/310-r.p.m. motors on the supplementary stand. The control of these machines is carried out through high response exciters reducing contactor equipment to a minimum.

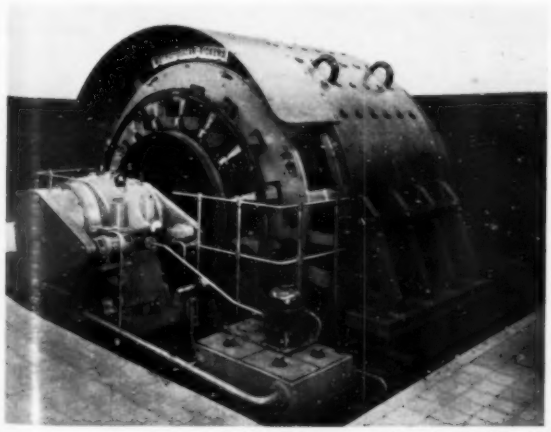
A non-reversing single-stand temper mill for stainless steel rolling in the Midlands will have a 300-h.p. main drive, two 164-h.p. reel drives, and associated motor-generator sets and control gear; metadyne exciters ensure accurate tension control. A processing line for softening and descaling stainless steel strip will be powered by D.C. motors totalling some 190 h.p. supplied from separate section generators with metadyne tension control on the coiler.

Electrical equipment for a double-duo rod mill to be commissioned next summer includes a 500-h.p., 300/900 r.p.m. main D.C. motor, whilst that in hand for an aluminium alloy cold reversing mill in Europe will have a 450-h.p. A.C. drive.

The accuracy of cutting on a flying billet shear equipment installed in South Wales has proved to be well within the guarantee given, and a further flying shear commissioned in India (and duplicated in North East England), is capable of cutting billets and sheet bar up to a maximum cross-section of 16 sq. in. at speeds up to 650 ft./min. Metadyne control enables the shear to be accelerated to full speed in 0·4 sec. and decelerated, after making the cut, in a similar time.

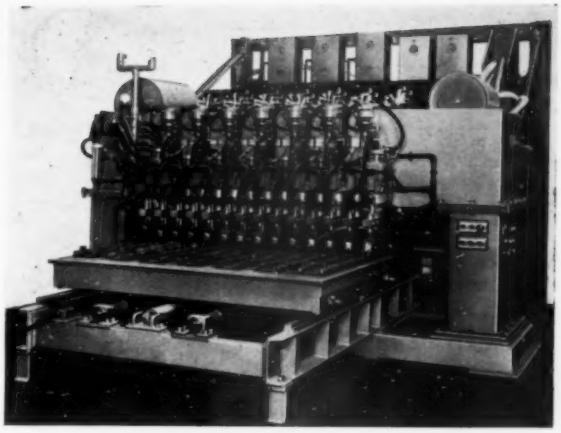
The billet length monitoring equipments soon to be completed will indicate accurately the length of hot billets after being sheared on the fly by a rotary billet shear. This is done by means of two photocells, which are spaced at the desired length of cut and mounted and screened to view the leading and trailing edges of the pieces. The accuracy required is of the order of ¼ in. in 30 ft. and an indicator is designed to display the error by needle deflection for about a second.

Rolling mill auxiliary drives on order for Turkey include drives for a blooming and section mill totalling 840 h.p. to be used in conjunction with two 3,100-h.p.



Courtesy of Metropolitan-Vickers Electrical Co., Ltd.

4,000 h.p. (10,000 h.p. peak) 50/120 r.p.m. D.C. motor driving a roughing mill in a South Wales steel works.



Courtesy of Metropolitan-Vickers Electrical Co., Ltd.

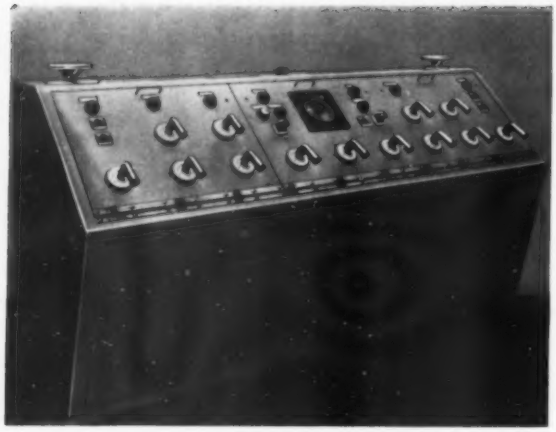
A fully-automatic 14-head air-operated spot welding equipment.

hot reversing mill drives supplied soon after the war. An order has also been received for auxiliary drives totalling 2,800 h.p. for a new 34 in. reversing mill, including two 350-h.p., 375-r.p.m. motors specially developed for the bloom shear. Control is on the Ward-Leonard metadyne system as is also the case for the breast roll, work table, screwdown and manipulator drives. A 4,000-h.p. slipring motor is being supplied to drive the motor generator set for existing mill equipments the original motor having been transferred to drive a hot mill.

Large numbers of auxiliary motors have been ordered for various projects, including the Colville expansion scheme at Ravenscraig, near Motherwell, the Richard Thomas & Baldwins developments at Ebbw Vale, live roll drives at South Durham Steel & Iron, the reconstruction of a 16-in. hot reversing mill in the North-East, and developments at the Australian Iron and Steel Company's plant at Port Kembla.

Among processing line equipments commissioned during 1954, is one for a coil side-trimming line at a steel plant in North Wales, and two others will follow shortly. Each line is designed to run at speeds up to 1,000 ft./min., and to handle coils weighing up to 20 tons. The electrical equipment comprises a 120-h.p., 360/1,200-r.p.m. motor for the two reels, a 120-h.p., 1,000/1,450-r.p.m. motor for the side trimmer, a 10-h.p., 600/700-r.p.m. motor for the pinch rolls, and a 12-h.p., 500/600-r.p.m. motor for the processor; these machines are supplied from Ward-Leonard controlled generators, the reel tension being controlled automatically by metadynes and transductor amplifiers.

Several processing line equipments have been ordered as a result of continued expansion of the steel industry in South Wales and work is well advanced on a new 74-in. strip pickling line, two new electrolytic cleaning lines, and the modification and speeding up of two existing strip pickling lines; altogether about a hundred and eighty D.C. and A.C. motors totalling over 6,000 h.p. are being supplied. The 74-in. line incorporates a new development in pickle tank catenary control in which transductors built into the brickwork in the bottom of the tank signal a magnetic amplifier according to the nearness of the strip, thus controlling the speed of the pinch roll motor via a metadyne and booster.



Courtesy of Metropolitan-Vickers Electrical Co., Ltd.

Centralised automatic control desk for rotary hearth billet heating furnace in a steel tube plant.

Blast Furnace Auxiliaries

Two blast furnace hoist equipments have recently been supplied, and a further equipment will be commissioned by the end of the year; one at a steelworks on the East Coast employs a 150-h.p. motor and is the first metadyne-controlled hoist to be supplied in this country. A fully automatic double-skip inclined hoist with a 90-h.p. motor has been commissioned in North Wales; it embodies improved sounding rod control, which will result in appreciable time saving in loading. Other advances that are being incorporated in new equipments include uniselector relays in place of solenoid-operated drum controllers, and a scheme for reversing the distributor drive that saves considerable time.

Twenty-four induction motors of types RS and RW ranging from 15 to 150 h.p. have been ordered for use on the new Guest Keen Iron and Steel ore handling scheme at East Moor, Cardiff.

Materials Transport

Electrical equipment has been delivered to Head, Wrightson for three 35-ton scale cars being built for Dorman Long, and also for a 35-ton scale car and a 50-ton transfer car for blast furnace extensions at the Shotton Works of John Summers & Sons, Ltd. The new Shotton equipments follow two transfer cars, two scale cars, and a hot metal ladle car recently put into service.

Orders have been received for electrical equipment for two 50-ton transfer cars and two 35-ton scale cars for overseas.

Induction Heating

A 12-kW. R.F. generator suitable for either dielectric or induction heating has been developed and embodies several new features. Two oscillator valves are used and can be operated either in parallel or in push-pull to suit the applicator circuits. The h.t. voltage is supplied from six mercury vapour thyratrons arranged as a three-phase bridge; grid control is employed to give variation of h.t. voltage over a wide range, and stabilization of h.t. and oscillator filament is included.

Equipment has been developed for induction hardening of gears by the scanning method, in which a small heating inductor is traversed at a controlled speed along each tooth in turn: at the end of each traverse an automatic mechanism indexes the wheel one tooth. Since only a small zone of metal under the inductor is heated at one time, the power requirements are small. This equipment is capable of hardening either straight cut or helical gears from 3 in. to 18 in. in diameter, and up to 6 in. in face width.

A number of H.F. motor generator sets have been put into commission for various steel melting and heat treatment applications.

Welding

A comprehensive arc welding installation being carried out for an East Coast yard building trawlers and factory ships includes ten 160-kVA. 12-operator welding transformers complete with reactors and ancillary gear. The standard 200, 300, 500 and 1,000 amp. single operator arc welding sets have been revised to conform to the new B.S. 638 : 1954, and a 400 amp. welder using metal rectifiers to provide D.C. is being developed.

A number of Metrovick automatic machines are suitable for both open arc and submerged arc welding, and existing open arc machines have been modified for submerged arc welding. For hand welding, the 6-ton manipulator has been redesigned to permit a 135° angle of tilt of the table, and the rotating mechanism can be fitted with electronic control, as can the 2-ton model.

The use of both automatic and hand welding with the atomic-hydrogen arc and the inert-gas-shielded arc processes continues to expand, the former finding a particular application in the chain-making industry.

The range of equipment in the resistance welding and heating field has been extended by the inclusion of all types previously made by British Insulated Callender's Cables, Ltd., and a rope parting machine has been redesigned for hydraulic instead of manual operation. Resistance welding machines made to special requirements include a large automatic flash-butt equipment for welding high-pressure alloy-steel tubes, and several multi-head spot welders, including a fourteen-head machine for welding steel flooring.

A large contract for resistance welding equipment for motor-car door and floor sub-assemblies covers four hydraulically-operated 25-ton multi-head machines of the press type, together with twenty-five die sets for these machines, and for five mechanically operated 24-ton presses; the presses being equipped by M-V with hydraulic gear and electrical control equipment, as well as welding guns and transformers.

Miscellaneous

Automatic Control.—A Salem Engineering rotary hearth furnace for Stewarts and Lloyds, Ltd., has been equipped for a complicated sequence of automatic control; testing and emergency use are provided for by a special selector switch, which gives either semi-automatic control (each part of the sequence is initiated by hand, completing itself but not initiating the next part of the cycle) or hand emergency control (any part of the sequence is initiated and completed as required).

Mercury Arc Rectifiers.—Large mercury arc rectifier equipments completed during 1954, include 800-kW. and 1,600-kW. air-cooled pumpless steel tank rectifiers for a large tube mill drive.

British Insulated Callender's Construction Co., Ltd., announce that the address of their Middlesbrough District Office is now 55/57, Borough Road, Middlesbrough (telephone: Middlesbrough 43644).

Frontage of Murex Research Department

Welding Electrode Research and Development

Extensions of Facilities at Murex

THE recently completed extensions to the research laboratories of Murex Welding Processes, Ltd., represent a further stage in the growth which has taken place since the first section of the laboratory block was built on the present site in 1938. With an area of some 28,800 sq. ft., the Murex Research Department is well equipped to meet the demands made upon it, and the new extensions, which have been designed to provide facilities for the increasing volume of research work carried out by the Department, reflect the great progress made by the welding industry in recent years.

Function of the Department

The main purpose of the Department is the development of new and improved electrodes to meet the ever increasing application of metal-arc welding, and its work can be sub-divided, broadly, into four main categories:—

(1) Basic research into problems associated with the raw materials used in the manufacture of metal-arc electrodes, and with the application of the arc-welding process itself.
(2) The development of new electrodes for new or unusual applications.
(3) The control of electrode quality, and the development of methods for facilitating the control of the quality of incoming raw materials and of the final electrodes.
(4) Technical service to customers and co-operative research with certain other research associations and organisations.

The work of each section is, of course, closely correlated with that of all other sections. The information gained during the course of a fundamental investigation into the effect of gases on weld metal quality, for example, can be of immediate value in the development of electrodes for welding the hardenable steels, and the problems involved in the control of electrode quality must, of necessity, involve the closest possible co-operation of all four groups of workers.

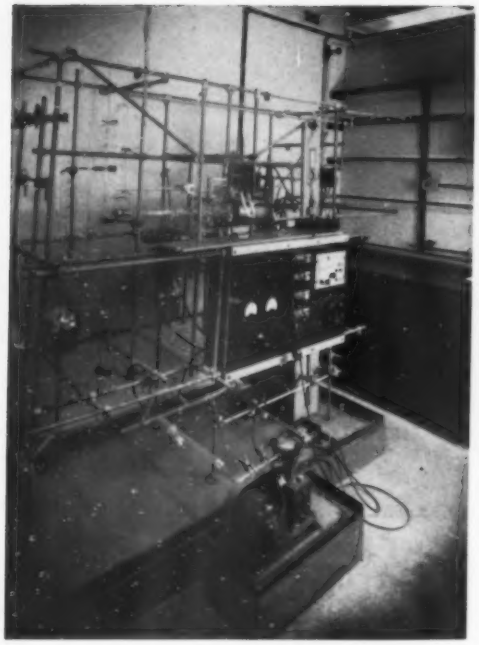
Separate laboratories are provided for the several aspects of the work of the Department, and in addition the welding school and lecture theatre are housed in the Research Department block.

Sectional Activities

Welding Research Section.

The main work of the welding research section is the testing of electrodes which are still in the development stage and which have not been released for general production; the evaluation of the suitability of estab-

One of the pilot plants in the Electrode Development Laboratory



Gas analysis apparatus

lished electrodes for unusual applications ; the provision of welding information required by customers ; and the quality control testing of factory-made electrodes.

The section is housed in a new laboratory which contains 17 individual welding cubicles and has an extensive free area equipped for large scale welding work and for the hot crack testing of weld metal using the Murex hot crack testing machine. The welding research laboratory contains suitable furnaces for preheating, and for the heat treatment of welded test pieces, and has attached to it a demonstration room in which welding demonstrations can be given to interested customers under suitably quiet conditions.

The welding cubicles incorporate features which are the result of many years of experience. They are constructed of 1½ in. fireproofed panels, framed in extruded aluminium sections, and are lined with asbestos. They contain such items as a special control panel with 8-in. A.C. and D.C. cirscale ammeters and voltmeters, power sockets for electric tools and recorders, push buttons for remote controlling current supplies from a motor generator set, indicator lights, direct current regulators, clockwork timers, adjustable bench lamps, transformer isolating switches and changeover terminals for various open circuit voltages.

There are special heating and ventilating arrangements provided, and either hot or cold air can be introduced into each cubicle as required. Fluorescent lighting, tool cupboards, adjustable seating and other adjuncts to good and efficient working conditions are provided.

Alternating current supply is provided by a Murex welding transformer and current regulator housed in each cubicle, but direct current is supplied by remote control from one of a number of Murex motor generator sets housed in a separate plant room. The isolation of all motor generator sets has obvious advantages in

Automatic welding laboratory

eliminating undue sources of noise from the welding shop.

Automatic Welding Section.

The growing interest of the company in electrodes and materials for use in automatic and semi-automatic welding processes has necessitated the incorporation of an automatic welding section in the extensions to the Research Department. This section is equipped with welding machines and ancillary equipment suitable for the development of electrodes for automatic welding. Welding currents of up to 1,500 amps. in either A.C. or D.C. supply are available for this work.

Electrode Development Laboratory.

This laboratory contains complete pilot equipment for the development and production of new and experimental electrodes. Stocks of the standard raw materials used in the factory, and also of unusual minerals and core wires, are held in store in the laboratory, and small batches of every kind of flux paste can be made in appropriate mixing machines. Such pastes can then be extruded on to suitable core wires, and the resulting flux-coated electrodes dried in drying ovens under carefully controlled conditions. The ball mills and sieving machinery used in reducing the minerals to a proper degree of fineness for inclusion in electrode coatings are housed in a separate room to minimise the noise and dust nuisance in the electrode development laboratory.

Test House.

The test house contains equipment for determining the mechanical properties of the metal to be welded, or of the joints made by welding. The main item is an Avery tensile testing machine capable of exerting a pull of up to 50 tons. Adjacent to it is a bend test machine in which welded specimens can be bent through various angles until a break appears. Other items of equipment comprise Izod and Charpy impact testing machines, a Wöhler type fatigue testing machine, a short time creep testing unit, and Vickers and Firth hardness testing machines.

Specimens are prepared in the machine shop for the various forms of testing—tensile tests, impact tests, bend

General view of the test house

Hilger quartz spectrograph

tests, etc.—to which welds and weld metals are subjected for the purposes of quality control and electrode development. In the adjoining metal stores, steel plates are the main bulk of the stock. Besides the steel plates in a dozen thicknesses, plates and sections of some thirty other alloys are available, each in several sizes and thicknesses.

Gas Analysis Section

The effect of the presence of gases, and particularly hydrogen, in weld metals has been the subject of much speculation throughout the world during recent years. In the non-ferrous metals the gas which is taken into solution during the time the metal is in the molten state may cause porosity in the metal if it is unable to escape before the metal has become solid. In the hardenable steels, hydrogen, in addition to causing porosity, can promote cracking in or adjacent to a weld when the material is welded under restraint.

Suitable apparatus has been constructed for the study of the effects of such gases as hydrogen and nitrogen on weld metals. In the apparatus in this section a sample of steel, either in the form of wrought material or weld metal, can be heated in an evacuated glass tube in a furnace and any gas which is dissolved in the steel freed into the tube. The gas can then be pumped out into a measuring system and in some instances it may also be analysed. Other apparatus for the study of the solubility effects of hydrogen in steel and for the determination of the total gas content of a steel by a vacuum fusion technique is under construction.

Metallurgical Laboratory.

This laboratory is used by the metallurgists engaged in the study of the metallurgical problems associated with the welding of steel, and the development of new ferrous electrodes. It communicates with a polishing room where specimens are prepared for microscopical examination. Certain hard facing deposits are too hard to be cut by the normal saw and a high speed slitting wheel is used in the preparation of samples of such deposits for microscopical examination. The slitting machine is housed outside the polishing room in the general laboratory.

Metallurgical microscopes are available for the examination and photography of metal specimens at all magnifications from 3 to 2,000. A suitably equipped dark room is available for metallographic and general photography and the Research Department contains smaller separate dark rooms for use by the X-ray and spectrographic sections.

Furnace Room.

The furnace room communicates with the metallurgical laboratory and contains suitable furnaces for the routine heat treatment of metal specimens and for heat treatment investigations. Certain stainless steel weld metals are commonly used at temperatures at which any ferrite contained in the austenitic matrix would transform to the brittle *sigma* phase, and a number of the furnaces are set aside for the quality control testing of such weld metals, to ensure that there is no undue formation of *sigma* phase in stainless steel weld metals destined for use in service at temperatures of the order of 650° C.

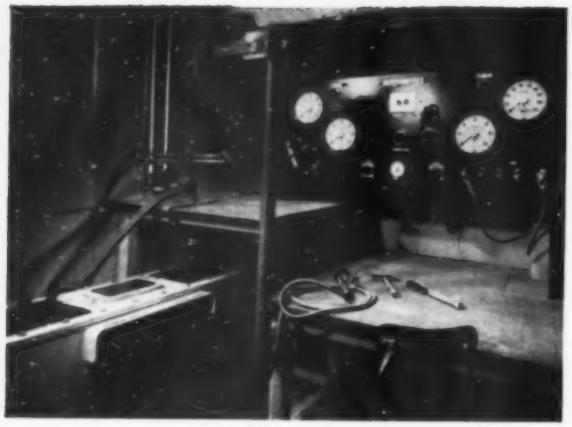
The furnace room also contains suitable ovens for studying the conditions required for the pre-drying of electrodes when weld metal of the highest quality is required.

Non-Ferrous Laboratory.

This laboratory houses the investigators engaged in the development of non-ferrous electrodes and the investigation of the associated metallurgical problems. It contains a flame photometer and a Reichert microscope which has been modified for macro-photography at magnifications of up to eight diameters. The lighting equipment on this latter apparatus is so arranged that various details of the surface of a specimen can be emphasised as required.

Radiographic Section.

Radiographic inspection is an important part of the quality control procedure for determining the cleanliness



Control panel and welding bench for development work

and soundness of weld metals and suitable radiographic equipment is available for this purpose. The processing and examination of the radiographic films is carried out in the adjacent dark room.

X-ray Diffraction Laboratory.

This laboratory contains a standard Raymax X-ray diffraction unit and ancillary equipment, which is used for crystallographic investigations with minerals and metals. The laboratory also houses a ferrometer, which is an instrument for measuring the magnetic properties of a metal sample and for distinguishing between the magnetic and non-magnetic phases in a steel. It is used for the examination of samples of stainless steel weld metals to determine the amount of magnetic ferrite in the non-magnetic austenitic matrix since, as already mentioned, the amount of ferrite can influence the properties of the steel in high temperature service.

Spectrographic Section.

This section is provided with a Hilger quartz spectrograph of large dispersion, which has been used for twelve years as a supplementary method of routine metallurgical analysis as well as for the rapid identification of various samples of metal. The positions of the lines on the spectrographic plates are identified on a spectrum comparator and their intensities measured on a microphotometer to give results from which the analysis of a specimen can be deduced by a graphical method.

Process Research Section.

The process research section is responsible for the investigation of some of the problems associated with the manufacture of electrodes and for the planning of certain electronic devices which may assist in the control of the manufacturing operations. The section is currently engaged upon the development of an equipment for measuring the electrical characteristics of the welding arc.

Chemical Analysis Laboratory.

This laboratory is responsible for the routine analysis of the many raw materials used in electrode production and of the weld metals deposited by ferrous and non-ferrous electrodes for quality control purposes. The balances are housed in a separate balance room at one end of the laboratory.

Instrument Workshop.

The maintenance and repair of the apparatus and instruments in use in the Research Department and the construction of certain new apparatus is carried out in a suitably equipped workshop and instrument repair room.

Library.

The library is well equipped with reference books on the many subjects involved in the development and production of metal-arc electrodes and receives a large number of technical journals each month.

Construction of the Building

The Research Department is housed in a single-storey building having a welded steel frame with Vierendeel and lattice girders supporting the larger spans. It has cavity external walls faced with Uxbridge flint bricks.

The roofing varies from steel decking to precast concrete slabs and hollow pots. All portions of the roof are covered with cork insulation and weatherproof mastic-asphalt. The floors are of concrete covered with granolithic finishes, tiles, composition, acid resisting asphalt or linoleum, according to the function of the particular section of the Department.

Experiments were made to determine the best colour scheme for those sections of the laboratory in which welding is carried out, and Myosotis blue with a reflectivity of about $\frac{1}{10}$ of white paint was chosen. This colour generally predominates throughout the department, with all pipe lines painted in the appropriate British Standard colours.

Correspondence

RECENT PROGRESS IN ALLOY AND SPECIAL STEELS

The Editor, METALLURGIA.

Sir,

In reading the article on " Recent Progress in Alloy and Special Steels," by G. T. Harris and E. Johnson, in your January, 1955 issue, I note the analysis of the steel in which vanadium has replaced molybdenum and is being developed by the British Welding Research Association.

It may be of interest to B.W.R.A. and others to know that many hundreds of tons of a similar steel were supplied for machineable armour during the War. The steel was supplied in the water-hardened and tempered condition, giving a Brinell number of approximately 380.

The structures were welded and no defects were encountered. It also gave great freedom from spalling under the firing tests.

Under the stress of alloy shortage, an attempt was made to replace the vanadium by molybdenum, but the resultant steel was not successful.

Yours faithfully,

ERNEST PASLEY,

Assistant Works Manager, Samuel Osborn & Co., Ltd.

Sheffield, 3. February, 1955.

BEMCO Glasgow Office

THE Glasgow office of the British Electro Metallurgical Co., is now situated at 266 Clyde Street, Glasgow, C.1 (Tel.: Central 6454), and Mr. W. Paton, the Company's field representative for Scotland and parts of Northern England will be available at that address.

NEWS AND ANNOUNCEMENTS

Portrait Presented to Institute of Metals

At a function on January 25th attended by members of Council of the Institution of Mechanical Engineers, the Iron and Steel Institute and the Institute of Metals, Dr. R. W. Bailey, President of the Institution of Mechanical Engineers, on behalf of the Institution, presented to the Institute of Metals a portrait of Sir William White, Founder President of the Institute in 1908.

In making the presentation, Dr. Bailey referred to the friendly link which had been maintained between the Institution and the Institute since the latter's formation almost 50 years ago. He had no doubt that there were many members who were common to the two societies, as were Dr. Dorey, the President of the Institute of Metals, and himself. Dr. Dorey, shared with Sir John Dewrance, Sir Henry Fowler and Sir William White, the distinction of serving as President of both the Institution and the Institute.

Dr. Bailey concluded by quoting from the Presidential Address of Sir William White on "The Institute of Metals: Its Origin and Objects":—

> "On your behalf I desire to publicly express the gratitude which the founders of the Institute of Metals feel towards the Council of the Institution of Mechanical Engineers for the generous and friendly attitude assumed by them towards the new Society; whose work will traverse a field, in the exploration of which the older Institution has been one of the pioneers (properties of non-ferrous metals) (properties of alloys of aluminium with other metals). We have been hospitably entertained in the house of the Institution of Mechanical Engineers and granted facilities for holding meetings of the Council and of members of the Institute. The President of that Institution has done us the honour of accepting a seat on our Interim Council, and in Mr. Harry Riches we find a colleague whose wide experience and great professional ability will be of immense value in the organisation of our Society. On many grounds it is important that this friendly feeling shall continue and grow, especially in the interests of the Institute of Metals."

Dr. Dorey replied, thanking the Institution of Mechanical Engineers on behalf of the Institute of Metals, and Dr. Maurice Cook, Senior Vice-President, seconded the vote of thanks.

Scientific Essay Competition

The Scientific Advisory Board of *Research* (Chairman, Lord Waverley) has decided for the third successive year to organise a "Science in Industry" Essay Competition. The purpose of the Competition is to encourage scientists to take greater interest in the problem of presenting the results of scientific research work to people less highly qualified than themselves.

The Competition is in two parts. The first part is aimed at drawing attention to the problem of the scientist in communicating with the industrial policy-maker. Often, the board of directors of an industrial firm contains no member with scientific or technical training, and scientists must learn how to put forward the case for the development or investigation of some new scientific process or project in terms which a technically unqualified board can appreciate. Competitors are required to make their case in an essay of about 3,000 words in length. Prizes amounting to £200 are to be awarded for this part of the competition. In addition, the author of the best essay will receive a special new award to be known as the Waverley Gold Medal.

The second part of the competition requires the scientist to discuss one of four set subjects in a manner suitable for publication in a general newspaper, and prizes amounting to £150 are to be awarded by the *Sunday Times*.

When the "Science in Industry" Essay Competition was first held in 1953 there were 34 entries. The winner was Dr. E. V. Truter of the Textile Chemistry Department, Leeds University, who described a new process for sorting molecules by size and shape. The second prize was won by Dr. David Williams who examined the causes of instability in two-wheeled trailers, such as caravans, and described a new design of tow bar which would obviate them.

The *Sunday Times* became associated with the 1954 Competition, which was run in two parts as is the present one. A further innovation was the decision to give a special prize of £50 for the best entry from a competitor under 30 years of age. The winner of the "Under 30" special award and also the first prize in the *Research* section of the competition was P. M. J. Gray. Mr. Gray is an Englishman who is at present working at the Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organisation, Melbourne, and his essay described an important new process for winning metals from lean ores. The second prize was won by Dr. J. J. Kipling of Hull University who wrote on new carbon absorbents.

Dr. H. M. Finniston, Head of the Division of Metallurgy, A.E.R.E., Harwell, won the first *Sunday Times* prize for his essay entitled "Atomic Energy and Industry." Second was Dr. G. D. Muir of The British Drug Houses Ltd., who described the use of power station waste products.

The total number of entries for both sections was 107.

Mond Nickel Fellowships

The Mond Nickel Fellowships Committee now invites applications for the award of Mond Nickel Fellowships for the year 1955. Awards will be made to selected applicants of British nationality educated to University degree or similar standard, though not necessarily qualified in metallurgy, who wish to undergo a programme of training in industrial establishments; they will normally take the form of travelling Fellowships—awards for training at Universities may be made in special circumstances. There are no age limits though awards will seldom be given to persons over 35 years of age. Each Fellowship will occupy one full working year. The Committee hope to award up to five Fellowships each year of an approximate value of £900 to £1,200 each.

Mond Nickel Fellowships will be awarded in furtherance of the following objects:—

(*a*) To allow selected persons to pursue such training as will make them better capable of applying the results of research to the problems and processes of the British metallurgical and metal-using industries.

(*b*) To increase the number of persons who, if they are subsequently employed in executive and administrative positions in the British metallurgical and metal-using industries, will be competent to appreciate the technological significance of research and its results.

(*c*) To assist persons with qualifications in metallurgy to obtain additional training helpful in enabling them ultimately to assume executive and administrative positions in British metallurgical and metal-using industries.

(*d*) To provide training facilities whereby persons qualified in sciences other than metallurgy may be attracted into the metallurgical field and may help to alleviate the shortage of qualified metallurgists available to industry.

Applicants will be required to state the programme of training in respect of which they are applying for an award, as well as particulars of their education, qualifications and previous career. Full particulars and form of application can be obtained from: The Secretary, Mond Nickel Fellowships Committee, 4, Grosvenor Gardens, London, S.W.1. Completed application forms will be required to reach the Secretary of the Committee not later than 1st June, 1955.

Aluminium Centenary Exhibition

In his article on "Aluminium in Britain is a Hundred Years Old," in the February issue, Dr. West mentioned that the aluminium industry was to present a Progress Exhibition later this year to mark the centenary of aluminium as a commercial metal in this country. This Exhibition, which is to be held at the Royal Festival Hall from June 1st to 11th, will also demonstrate how the present vast output and unique experience already gained are now being applied to every great industry in increasing measure, and illustrate the research and development sponsored by the aluminium industry and The Aluminium Development Association completed during the past ten years.

The Exhibition is primarily directed to all present and potential users of aluminium, particularly to professional engineers, designers and architects, representatives of government, local authorities, and the great industries of Britain; to Commonwealth and foreign guests; and to teachers engaged in university and higher technological education.

The historical section of the Exhibition will tell the story of the early scientists and of the first disclosure, in 1855, of the chemical process that led to the production of the metal in Britain. It will also show the transition from the chemical to the electrolytic process, from 1886 onwards. The story is continued to the present day, with the discovery of the principal alloys and their commercial adoption.

The aluminium industry has been built on research, and the research section will illustrate, accurately, but in simplified form the sound scientific basis of the industry, whilst the production section will demonstrate, by diagrams and models, how aluminium is extracted and fabricated into semi-finished forms, together with the products resulting from each process. A statistical exhibit will show the location of the ore (bauxite)—also world production and output in the U.K.

The largest section of the Exhibition, dealing with the present day use of aluminium, will answer the question: "Why is aluminium used for X or Y or Z?" It will cover all fields of application and will be illustrated, not only by photographs, drawings and models, but, whenever possible, by actual full-scale examples of road and rail vehicles, boats, chemical and electrical plant, etc.

The remaining section will take a peep into the future. On several days technical discussions will be held during the afternoon, summarising progress and future possibilities in the use of aluminium in shipbuilding, road transport, railways, structural engineering, building, packaging, electrical engineering, etc. The audience for these papers will be professional men, and experts in the respective industries, specially invited to the Exhibition and to contribute to the discussion.

Protection of Structural Steel Symposium

Organised by the Corrosion Group of the Society of Chemical Industry, a Symposium on the Protection of Structural Steel will be held on Thursday, March 31st and Friday, April 1st, at the Institution of Civil Engineers, Great George Street, London, S.W.1. Details of the papers to be presented for discussion appeared on page 290 of our December issue. In addition, there will be, on the evening of March 30th, the Corrosion Group Spring Lecture for 1955 delivered by F. L. LaQue, Vice-President and Manager of the Development and Research Division of the International Nickel Company, Inc., with the title of "Attention to Corrosion in the United States." A conference fee of £2 will be payable by non-members of the Society of Chemical Industry, who are required to register before March 25th, 1955. Further particulars can be obtained from the Assistant Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

Non-Destructive Testing Conference

An International Conference on Non-Destructive Testing of Material is to be held in Brussels from May 23rd to 28th, 1955, under the auspices of L'Association Des Industriels De Belgique in co-operation with European and American technical organisations. The aim of the Conference is to discuss the present state of the non-destructive testing methods of material, from the standpoint of scientific research, industrial application and education. It will also deal with the international aspects of co-operation in exchange of information, thereby contributing to improved economy, design, application, and safety of non-destructive testing. The main technical subjects to be discussed will be radiography, ultrasonics and magnetic particle inspection, but other testing methods will also be discussed, such as eddy current techniques, thickness measurement devices, etc. The co-operating organisation in this country is the Non-Destructive Testing Group of The Institute of Physics.

Corrosion Lectures

A course of five lectures on "Corrosion and Protective Measures for Buried and Submerged Structures" will be delivered by Mr. K. A. Spencer at the Northampton Polytechnic, St. John Street, London, E.C.1 on Monday

evenings at 7 p.m. On March 7th the subject will be "The Mechanism of Corrosion of Buried and Submerged Structures"; on March 14th, "Coatings for Buried and Submerged Structures"; on March 28th and April 25th, "Cathodic Protection Methods"; and on May 2nd, "Correlation of Cathodic Protection with Engineering Structural Design." The fee for the course is £1 1s. 0d.

Institute of Welding Meeting

THE Annual Spring Meeting of The Institute of Welding is being held this year in the East Midlands area, and will comprise, as usual, a number of works visits and technical sessions. Visitors will be welcome at the technical sessions which are being arranged for the Friday and Saturday mornings at the University of Nottingham. On Friday, April 29th, papers on "Castellated Construction," by H. Saunders, and "Residual Stresses in Welded Structures," by G. M. Boyd, will be presented, along with a film "The Tubewright" with commentary by Dr. J. S. Blair. The papers for discussion on Saturday, April 30th, are "Welding of Carbon Steels by the Argonaut Process," by A. W. Stones and H. F. Tremlett, and "Oxy-acetylene Pressure Welding of Aircraft Undercarriage Components," by J. J. Wilson and D. C. Brown.

Polarographic Society

FORMED towards the end of last year to advance and promote the science of polarography in all its aspects, and to provide educational facilities in polarography through discussion and any other medium, the Polarographic Society held its first meeting of the session on February 17th, when the following papers were read: (1) "The Application of the Polarograph in the Analysis of Fine Chemicals," by J. T. Yardley and A. G. Morris; (2) "From Engineering to Polarography," by C. L. Wilson; and (3) "The Reduction of the Aromatic Nitro Group—A Suggested Mechanism," by Dr. J. G. Waller. Membership of the Society is open to anyone interested in polarography, the annual subscription being 10s. The Hon. Secretary is Mr. B. Lamb, 25, Grittleton Avenue, Wembley, Middlesex.

Methods of Analysis Panel

THE Absorptiometric Panel, Glasgow, announces that in future its title will be "Methods of Analysis Panel (Glasgow)." This change has been made in order to extend the scope of its activities, particularly with reference to inorganic analysis. The first meeting of the new Panel will be held at the Royal Technical College, Glasgow, on Friday April 22nd, 1955, at 2.30 p.m. Anyone interested, or who desires to attend the first meeting, should inform Mr. E. K. Ballantyne, Colvilles, Ltd., Clydebridge Steel Works, Cambuslang, Scotland (Tel.: Cambuslang 630), from whom further information can be obtained.

T.I. Research Fellowship

APPLICATIONS are invited for the T.I. Research Fellowship tenable in the Department of Metallurgy in the University of Sheffield. The object of the Fellowship is to advance knowledge in the field of metallurgy, and although candidates should already have some research experience, it need not necessarily be in this field. Normally, the tenure will be for five years, but the appointment will be for two years in the first instance and thereafter will be renewable annually. The stipend is £750 per annum for the first year, rising by annual increments of £50 to £950 per annum, together with superannuation provision under the F.S.S.U.; a higher stipend may be paid to an exceptional candidate. Further particulars can be obtained from the Registrar The University of Sheffield, by whom final applications, including testimonials, etc., should be received not later than March 31st, 1955.

Cantor Lectures

THREE Cantor Lectures on "The Mechanical Properties of Metals" will be delivered at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, on Mondays, March 14th, 21st, and 28th, 1955, at 6 p.m. The first, by Professor Hugh Ford, will deal with tensile properties; the second, by Professor E. N. da C. Andrade, with creep; and the last, by Major P. Litherland Teed, with fatigue. The three lectures will be printed together in the Society's Journal in due course.

Higher Fees for Patents and Designs

FROM 1st February, 1955, higher renewal fees will be charged for patents and design registrations due to expire after 30th April, 1955; and after that date there will be a general increase in fees payable in respect of a number of patent and design matters. These fees have remained substantially unchanged for many years despite considerable increases in administrative costs.

This change is announced by the Board of Trade who have laid before Parliament revised Rules which amend those made under the Patents Act, 1949, and the Registered Designs Act, 1949. In addition to providing for higher fees, the Patents Rules have also been amended in minor respects to make them conform to the requirements of the European Convention of 11th December, 1953, relating to the formalities required for patent applications.

Whitney Award for Dr. Vernon

SHORTLY before leaving America to attend the Symposium of the Corrosion Group of the Society of Chemical Industry in London, Mr. F. L. La Que was charged with a special commission by the National Association of Corrosion Engineers. This was to convey this year's Whitney Award to Dr. W. H. J. Vernon, O.B.E., who recently retired from his post as Head of the Corrosion Section of the Chemical Research Laboratory of the D.S.I.R.

The formal announcement of the award was made at the Association's annual dinner at Chicago on March 9th, and Mr. La Que, who is Vice-President and Manager of the Development and Research Division of the International Nickel Co. Inc., will make the actual presentation on the occasion of delivering the Corrosion Group's Spring Lecture for 1955 on the evening of Wednesday, March 30th, at Church House, Westminster.

The Whitney Award, presented annually by the N.A.C.E. for distinguished contributions to corrosion science, has only once previously come to this country, when Dr. U. R. Evans was the recipient in 1948.

Personal News

English Steel Corporation, Ltd., announce appointments to the Boards of the following five newly-formed subsidiary companies. English Steel Forge and Engineering Corporation, Ltd.: Mr. F. Pickworth (Chairman); Mr. W. D. Pugh (Managing Director); Mr. F. S. Beale (Director); Dr. H. H. Burton (Director); Dr. C. J. Dadswell (Director); Mr. G. Gilfillan (Director); Mr. W. E. A. Redfearn (Director). English Steel Rolling Mills Corporation, Ltd.: Mr. F. Pickworth (Chairman); Mr. R. G. H. Taylor (Managing Director); Mr. H. Scholey (Director and General Manager); Mr. F. S. Beale (Director); Mr. W. D. Pugh (Director). English Steel Castings Corporation, Ltd.: Mr. F. Pickworth (Chairman); Dr. C. J. Dadswell (Managing Director); Mr. F. S. Beale (Director); Mr. W. C. Muirhead (Director); Mr. W. D. Pugh (Director). English Steel Spring Corporation, Ltd.: Mr. F. Pickworth (Chairman); Dr. C. J. Dadswell (Managing Director); Mr. F. S. Beale (Director); Mr. W. C. Muirhead (Director); Mr. W. D. Pugh (Director). English Steel Tool Corporation, Ltd.: Mr. F. Pickworth (Chairman); Mr. R. G. H. Taylor (Deputy Chairman); Major-General E. P. Readman (Managing Director); Mr. F. S. Beale (Director).

Mr. C. J. Williams has been appointed to succeed Mr. J. A. Wellings as Manager of the Casting Division of High Duty Alloys, Ltd. Mr. Wellings has taken up an appointment as Director and Vice-President of Canadian Steel Improvement, Ltd., in Toronto.

Mr. H. H. Smith, Assistant Manager of the Special Vessels Department of Babcock & Wilcox, Ltd., has been appointed Sales Manager of Edwin Danks & Co. (Oldbury), Ltd.

Mr. C. Watts has been appointed Sales Manager (Foundry) of the Distington Engineering Co., Ltd., Workington.

Mr. F. C. Smith, until recently Technical Manager of A. R. Wade, Ltd., is now Director of Sintering and Brazing Furnaces, Ltd., a new company with offices at 272/3, Terminal House, Grosvenor Gardens, London, S.W.1, and Works at 124/30, Edinburgh Avenue, Trading Estate, Slough.

Metropolitan-Vickers Electrical Co., Ltd., announce that Mr. R. P. Horlock has transferred to Metropolitan-Vickers Electrical Export Co., as Manager for Canada. Mr. Horlock has been succeeded by Mr. R. S. D. Bagnall, who is now Manager, Sheffield Office.

Mr. B. J. Terrell has been appointed to the position of Senior Designer at the Pametrada Research Station at Wallsend. He is succeeded as Senior Research Engineer by Mr. R. F. Darling.

Mr. G. G. Baldwin has taken up an appointment as Agricultural Machinery Adviser of the Tractor Division of The David Brown Corporation (Sales), Ltd., and Mr. A. J. Warde Dixon has been appointed Export Sales Manager.

Mr. T. M. McKinlay has joined Polygram Casting Co., Ltd., as Technical Representative for Polygram Shell Moulding Equipment in the North of England.

Mr. J. Hews, 57, Arnold Avenue, Coventry, has been appointed Midlands Representative of J. E. Baty & Co., Ltd.

The Directors of The Effingham Steel Works, Ltd., announce that Mr. O. W. Mortimer, their Representative for Yorkshire (W.R.), Lancashire and North Midlands, is now a Local Director of the Company.

Mr. D. Colbridge, formerly Chief Methods Engineer to the David Brown Foundries Company has been appointed to a similar position with A.P.V.-Paramount, Ltd.

The General Electric Co., Ltd., announces that Mr. R. N. Millar, lately Chief Mechanical Engineer to The British General Electric Co. (Pty.), Ltd., Australia, has been appointed to take charge of its newly-formed Industrial Atomic Energy Section which is located at the Company's Erith works.

Dr. H. G. Taylor, Director of Research of the British Welding Research Association since 1947, has been elected President of the Society of Engineers. In his Presidential Address, Dr. Taylor spoke on the history of resistance welding.

Mr. B. N. H. Thornely, a Director of Northern Aluminium Company, Ltd., has been made Secretary in addition to his present duties. Mr. E. A. Trigg, formerly with Aluminum Company of Canada, Ltd., has been appointed Chief Financial Officer, and Mr. J. Mason, formerly Assistant Treasurer, is now Chief Accountant.

The Board of Directors of Head, Wrightson & Co., Ltd., announce that Mr. R. B. W. Bolland has been appointed a Director of Head, Wrightson Aluminium, Ltd. Mr. Bolland retains his position as General Manager of the subsidiary company.

Obituary

We regret to record the death of the following:—

Mr. David A. Bremner, O.B.E., who died on February 7th in his 89th year. Mr. Bremner was Director of The British Engineers' Association from 1919 to 1943, during which period he was closely connected with many industrial organisations. Prior to 1919, he had for many years been closely connected, both in the U.K. and overseas, with mechanical and electrical engineering, and for a time was General Manager of the Dunderland Iron Ore Company of Norway and General Manager of the Hydraulic Power and Smelting Company. Mr. Bremner received the decoration of O.B.E. for services rendered during the first World War as Head of the Aluminium Section of the Ministry of Munitions.

Mr. C. B. Perkins, who died at Weymouth on December 14th at the age of 79 years. Mr. Perkins, who had been in semi-retirement for the past eight years, was for over 40 years the Representative in this country of the steel works of George Fischer, Ltd., Schaffhausen, Switzerland, and during the years 1940 to 1950 of the Malleable Castings Division of Britannia Iron and Steel Works, Ltd., Bedford.

Mr. R. Eccles, Branch Manager of British Insulated Callender's Cables, Ltd., in Glasgow, who died at the age of 57. Mr. Eccles joined the former British Insulated Cables, Ltd., in 1928, and on the formation of British Insulated Callender's Cables, Ltd., in 1945 he was appointed Transmission Engineer for Scotland, a position he held until 1953 when he became Branch Manager of the Glasgow Office.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

Gear Roll Tester

FIRST of a range of similar machines to be built by The David Brown Tool Company, the David Brown No. 24 gear roll tester is designed to provide a simple, rapid and positive means of checking concentricity, tooth contact, centre distance and varying tooth thickness of gears up to 24 in. External or internal spur and helical gears are accommodated by the standard model, while separate heads—mounted on the adjustable carriage—are available for shaft gears, bevel gears and worm gears.

Of extreme precision and simplicity, the machine is ideal for repetition work (using a master gear) or for checking master gears themselves. Readings are registered on a dial indicator, sensitive to 0·00005 in., while centre distances are read directly from a vernier scale.

The tester comprises three main components—the bed, an adjustable carriage and a sensitive carriage. The adjustable carriage can be locked in any position on the bedplate and carries a vernier scale used in conjunction with the scale on the sensitive carriage. The latter carriage is located on four balls mounted in hardened and ground guideways to ensure complete freedom of movement. It operates against spring pressure which can be exerted in either direction to allow for external and internal gears. Movement of this carriage can be read on the dial indicator.

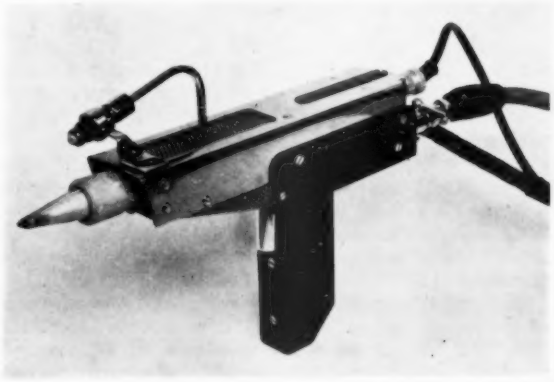
Gears are tested by rotating them together in pairs. When quantities of gears are to be tested it is recommended that one of the gears should be a master or one that is known to be correct. Using the respective arbors, the adjustable carriage is moved along the bed to bring the gears into mesh. It is then clamped in a position where it will exert a slight spring pressure against the sensitive carriage.

To ensure freedom of movement and also to minimise the risk of wear it is advisable to place the gear of least weight on the sensitive carriage. On rotation, any variation in concentricity or tooth thickness is immediately registered on the dial indicator and the centre distance at which the gears are meshing is read on the vernier scale. For batch inspection, the adjustable carriage is returned to the same position after each gear is checked, by using the stop fitted to the bed. Backlash can be calculated by noting the difference between the working centre distance and the centre distance when the gears are in metal to metal contact.

The David Brown Corporation (Sales) Ltd., Park Works, Huddersfield.

Ultrasonic Soldering Iron with Gas Jet

WHEN using the Mullard ultrasonic soldering iron to apply solder to large masses of aluminium and similar "difficult" metals, it is necessary to pre-heat the work to the required temperature. When very large metal parts are to be soldered, as in the case of large castings requiring repairs to surface defects, the best way to apply additional heating is by playing a gas jet on the surface of the metal close to the point where the bit of the iron is being applied. To enable this work to be done and at the same time leave the operator with a free hand, the Equipment Division of Mullard Ltd., are now making available a gas jet attachment for their ultrasonic soldering iron. The gas jet is automatically played on exactly the right part of the work, and the operator can use his free hand to hold a tool or a stick of solder, etc. The flow of gas is controlled from a small tap on the attachment.



Mullard, Ltd. Century House, Shaftesbury Avenue, London, W.C.2.

New Standard Sample

A NEW standard sample No. 167, of cobalt-base heat-resisting alloy is now available from the National Bureau of Standards, Washington, D.C., U.S.A., with a provisional certificate of analysis for the following constitutents: C, 0·38%; Mn, 1·64%; P, 0·010%; S, 0·007%; Si, 0·44%; Cu, 0·03%; Ni, 20·65%; Co, 42·90%; Fe, 2·13%; Cr, 20·00%; V, 0·01%; Mo, 3·90%; W, 4·50%; Nb, 3·15%; Ta, 0·08%. The price of this standard is $5 per 150-g. unit.

CURRENT LITERATURE

Book Notices

FATIGUE TESTS ON ROLLED ALLOY STEELS MADE IN ELECTRIC AND OPEN HEARTH FURNACES

By P. H. Frith, A.Met., F.I.M. A report of the British Iron and Steel Research Association. Iron and Steel Institute Special Report No. 50. 130 pp., 22 plates, cloth boards. 25s.

THIS report gives the detailed results of more than 13 years study of the fatigue problem in relation to high-quality steels. Originally instituted by the Inclusions Sub-Committee of the Iron and Steel Institute, to investigate the practicability of measuring the standard of cleanness of aircraft steels through a numerical count —especially by the so-called " Fox Inclusion Count "— the work eventually became the responsibility of the Fatigue and Inclusion Committee of B.I.S.R.A.'s Metallurgy (General) Division.

Studies of steels heat-treated from 60 to 110 tons/sq. in. U.T.S. show that inclusions of the size and type present appeared to have no detrimental effect on the properties of steels with an ultimate tensile strength of 60 tons/sq. in. Observations suggest that extraneous inclusions in more massive form would probably be detrimental. The effects of the inclusions present grew progressively more marked in steels with a greater U.T.S., the type of inclusion producing the greatest decrease in fatigue-resistance appearing to be un-deformed spherical silicates. It was found, for example, that these inclusions reduced the longitudinal fatigue limit of basic electro-arc normal-procedure steels, heat-treated to 110 tons/sq. in. U.T.S. by at least 17%.

The report also includes the results of similar studies of chromium-carbon steels heat-treated to a hardness of 750 D.P.N. Besides conventional metallographic methods, the micro-radiographic technique was also employed throughout the investigation. Although more laborious, micro-radiography can in some circumstances be more informative.

The report is divided into a synopsis and introduction, and chapters on details of materials used, fatigue tests, tensile tests, magnetic and X-ray diffraction tests, current and magnetic flow tests, metallographic tests, micro-radiographic tests, and discussion of results. It includes 57 tables, 22 plates and a list of references.

Trade Publications

THE practice of silver plating is now more than a century old and during that period definite basic principles have emerged. The object of a new 36-page book published by Johnson, Matthey & Co., Ltd., is to outline in a brief and practical manner the various operations that may be required to produce satisfactory results. It endeavours to include suitable methods for most requirements, as well as some warnings of possible pitfalls. Broadly speaking, the processes involved in silver plating may be divided into three main groups—preparation, pla ing and finishing—and it is into these sections that the subject matter is divided, apart from a section on plating troubles.

PUBLICATION 5416 recently issued by Crofts (Engineers), Ltd., Bradford, 3, deals with the company's range of medium and heavy duty cast iron conveyor pulleys. They are available in single or double arm or plate centre construction, dependent on the belt width, and as taper (convex) faced or flat faced pulleys. The standard sizes range from 12 to 60 in. diameter, with face widths varying from 16 to 64 in., but special pulleys can be made to meet customer's requirements. Rubber lagged pulleys can be supplied to meet those conditions where the materials handled have an adverse effect on the normal driving efficiency of the pulley, the rubber lagging greatly increasing the effective grip on the belt.

THE past year has seen important changes at Dorman Long, in both the operating units and the company organisation. The new Lackenby steel plant is now in full operation and, as a consequence, the melting shop at the Britannia Steel Works, the cradle of Dorman Long, has teemed its last cast, bring the total steel production there to a figure of 10,766,318 ingot tons. These and other developments are referred to in D.L. Illustrated, 1954, as is also the change in organisation whereby Dorman Long (Steel), Ltd., Dorman Long (Bridge and Engineering), Ltd., and Dorman Long (Chemicals), Ltd., came into being.

THE latest leaflet issued by Coupe & Tidman, Ltd., who are associated with The Morgan Crucible Co., Ltd., is concerned with refractory strainer cores for use in the production of slag-free castings in the foundry. It is claimed that they do not erode or spall, do not collapse during pouring and do not gas the metal. A range of sizes is available, extending from 1½ in. O.D. to 3½ in. O.D., and special sizes can be made to order.

WE have received from Sanderson Brothers & Newbold, Ltd., Leaflet M.E. 32 dealing with the range of Saben Tenco Butt Welded Tools. The cutting portion is of 10% cobalt high speed steel, and this is electrically butt welded to the tough carbon steel shank. The shapes in which these tools are available are shown, and for each shape number the shank section, overall length and price are detailed.

Books Received

" Electrolyte Solutions " (The Measurement and Interpretation of Conductance, Chemical Potential and Diffusion in Solutions of Simple Electrolytes). By Dr. R. A. Robinson and Dr. R. H. Stokes. 512 pp. inc. index. London, 1955. Butterworths Scientific Publications. 56s. net. By post 1s. 8d. extra. The American edition of this book is published by Academic Press, Inc., 125, East 23rd Street, New York, 10, N.Y.

" Strength and Resistance of Metals." By John M. Lessells. 450 pp. inc. subject and author indexes. New York and London, 1954. John Wiley and Sons, Inc., and Chapman and Hall, Ltd. 80s. net.

" Fluid Dynamics and Heat Transfer." By James G. Knudsen and Donald L. Katz. University of Michigan. Engineering Research Institute Bulletin No. 37. 243 pp. inc. index. Michigan University Press (London: Geoffrey Cumberlege), 1955. 36s. net.

LABORATORY METHODS

MECHANICAL • CHEMICAL • PHYSICAL • METALLOGRAPHIC

INSTRUMENTS AND MATERIALS

MARCH, 1955 Vol. LI, No. 305

New Portable Hardness Testers

Vickers Introduce General Purpose and Gear Tooth Models

FOR many years now, the Vickers Pyramid Hardness Testing Machine has been a familiar sight in metallurgical laboratories and test houses, where it is used for determining the hardness of metals, and although it is capable of taking a wide range of specimens, there is some work which is either too large or too heavy for easy access to the standard machine.

To meet the need for means of testing such work, the makers of the standard machine, Vickers-Armstrongs, Ltd., of Crayford, Kent, have introduced two portable machines, one for general testing and one for testing on the pitch line of large gear wheels. As in the case of the standard machine, the impression is made by a pyramid diamond, but instead of a series of levers a spring is used in conjunction with a hydraulic system to apply the load.

General Purpose Portable Hardness Tester

This instrument, which incorporates several patented features, consists fundamentally of an indenting unit, with a standard diamond indenter, and a microscope for measuring the impression, both of them being carried on an adaptor unit (Fig. 1). Two alternative indenting loads, 10 kg. or 30 kg., are readily available by the turn of a knob. Adjustable chain clamps are supplied as standard, although other methods of fixing can be used. Guard strips are fitted to prevent damage to the diamond of the indenter should the unit be inadvertently lowered too heavily onto the specimen.

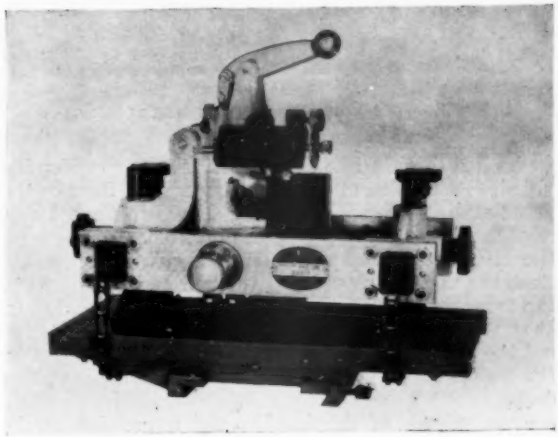


Fig. 1.—The general purpose portable hardness tester.

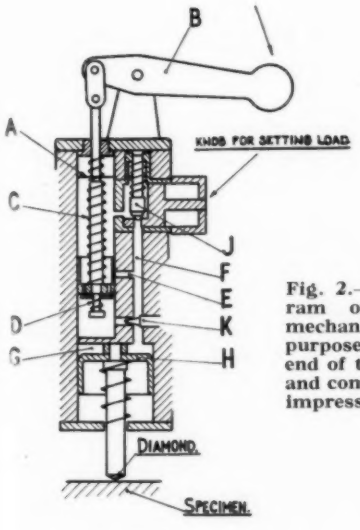


Fig. 2.—Schematic diagram of the indenting mechanism of the general purpose instrument at the end of the manual stroke and commencement of the impression stroke.

Indenter Unit.—Externally, the indenter unit consists principally of the body, top and bottom covers, and operating handle, all of light alloy, and the indenter, which is of standard pattern. The operating piston and the indenting piston are of toughened steel and work in bronze bushes. The pistons are ground to an extremely fine clearance and are finally lapped to their respective bushes, in order to combine closeness of fit with freedom of operation.

The main operating spring is of double telescopic form, to obtain minimum load variation within its range of deflection. This spring also supplies the load for compressing the gland for the operating piston rod, no adjustment of this gland being required during the life of the packing. The load valve spring is of piano wire, stress-relieved to ensure continued accuracy of load. This spring is of very small gauge wire with a large number of coils, giving a negligible load variation for its small working deflection.

The rotary valve seating, the turning of which by an external knob provides two loads, is of toughened steel working in a bronze bush. The steel load valve is case-hardened at its contact point with the rotary seating.

Oil tightness is obtained by the provision of gaskets at all necessary external joints and the indenter piston is sealed off from external leakage by means of a collapsible reservoir.

The operating handle of the tester is coupled directly to a spring-loaded compression piston, which is, in turn, connected hydraulically with the indenting piston and diamond. The unit is filled with oil to approximately

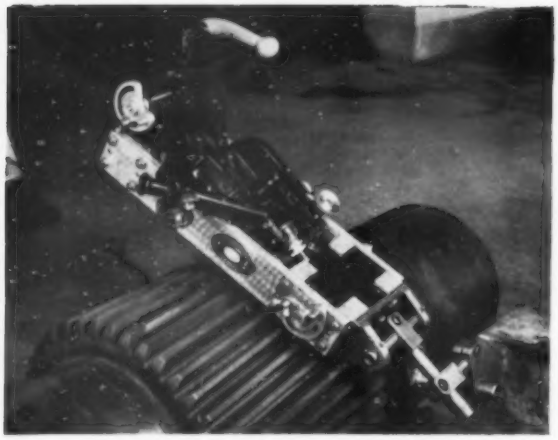


Fig. 3.—The portable gear hardness tester.

the level *A* (Fig. 1), one charge lasting for a considerable period. Depression of the operating handle *B* raises the piston and compresses the spring *C*, which is capable of providing a load in excess of the rated load of the unit. The inequalities of pressure on each side of the piston cause the non-return valve *D* to open and permit oil to flow from the exhaust to the compression space below it. At the end of the manual stroke the pressures are equal and the valve *D* closes under the influence of its spring. The by-pass *E* is closed by the piston throughout this stroke.

Upon release of the handle, the impression stroke commences. The piston is moved downwards by expansion of the spring *C*, and oil is forced into the load valve chamber *F* and the indenter-operating cylinder *G*, causing the light spring behind the piston *H* to be compressed until the indenter comes into contact with the work. Immediately contact is made, the pressure builds up in the system until the full indenting load is being applied to the diamond. When the full load is reached, the valve *J*, which can be adjusted for release pressure, prevents any further increase by opening slightly against its spring and allowing oil to flow to the exhaust space.

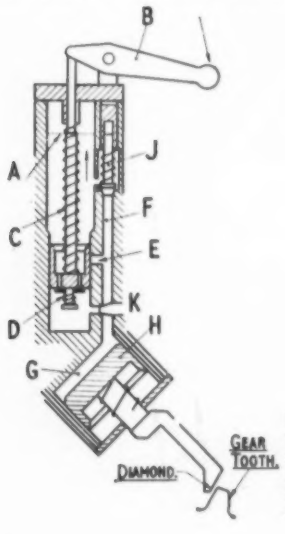


Fig. 4.—Schematic diagram of the indenting mechanism of the portable gear tester at the end of the manual stroke and commencement of the impression stroke.

At the end of its stroke the piston uncovers the port *A*, and the pressure is released, oil being permitted to flow into the exhaust space when the light spring returns the indenter piston to its retracted position ready for the next operation. The load valve spring is pre-set to give the correct load, and no further adjustment is necessary unless correction of the load is required. The impression period of approximately 10 seconds is controlled by the adjustable throttle-type valve *K*, which is locked after setting to ensure constant conditions for each impression.

Microscope.—In order to obtain a compact assembly, with a minimum amount of adjustment between the indenter and the microscope objective, a horizontal objective extension is fitted to the microscope. By a system of reflectors, this, in effect, brings the objective to a distance of only 0·6 in. from the indenter. Thus it is necessary only to move the microscope a distance of 0·6 in. in order to measure the impression. Apart from this horizontal extension, the microscope is very similar to that used on the standard hardness testing machine. It is rigidly attached to the indenting unit by means of a light alloy bracket, from which it is readily detachable.

Adaptor.—The adaptor, or carriage, is built up of a pair of duralumin side plates secured to and spaced apart by two light alloy brackets. Each of these brackets houses a vertical steel tube projecting below the adaptor, each tube having a specially shaped steel foot attached. These feet support the tester on the specimen, and are adjustable for height, in order to obtain the correct spacing between indenter and specimen. The indenting unit is mounted in the adaptor in a pair of steel bearings, one secured to each side plate. A short steel spindle projects from each side of the indenting unit. These spindles are in line, and each projects through one of the above bearings.

It is so arranged that the indenting unit can slide transversely between the side plates for a distance of 0·6 in., this being the amount required to bring the objective into position over the impression. Ball catches acting on grooves in the mounting spindles retain the indenting unit in either position.

Gear Tester

The Vickers Portable Gear Hardness Tester is very similar to the general purpose instrument, but the load cylinder is set at an angle to the indenter-operating cylinder, as will be seen in Figs. 3 and 4. A special clamp is supplied with the instrument which can be readily assembled on most gears and allows the instrument to be easily adjusted to the angle of the tooth being tested. Unlike the general purpose instrument, only one load (30 kg.) is available.

Larke Medal Papers on Welding

THE Council of the Institute of Welding announces that papers to be considered for the award of the Sir William J. Larke Medal of the Institute for 1955 must reach the Secretary at the Institute's offices, 2, Buckingham Palace Gardens, London, S.W.1, not later than April 30th, 1955. Particulars of the regulations for the award of the Medal, for which non-members as well as members of the Institute may compete, may be had from the same address.

BRITISH INSULATED CALLENDER'S CABLES LTD. announce that the telephone number of their Reading Branch Office is now Reading 55074/5.

The Photometric Determination of Zirconium in Hiduminium RR.350 and Similar Alloys

By E. C. Mills, F.R.I.C. and S. E. Hermon

Research and Development Division—High Duty Alloys Limited, Slough

Because of the difficulties of time and expense attached to gravimetric determination of zirconium in aluminium alloys, photometric methods have been examined. A technique using alizarin-S has been devised and found satisfactory for foundry control purposes.

THE continuous efforts to improve aluminium alloys for engine components operating at elevated temperatures has led to the development of certain complex aluminium alloys containing zirconium. A typical alloy of this type is Hiduminium RR.350, which has the following nominal composition.

Copper	5·0%
Nickel	1·0%
Manganese	0·25%
Cobalt	0·25%
Antimony	0·25%
Zirconium	0·25%
Titanium	0·20%
Aluminium	Remainder

A range of 0·1–0·4% zirconium has been encountered in experimental work but 0·2–0·3% are the more usual limits experienced in production control.

For the determination of zirconium, various phosphate and mandelic acid gravimetric methods have been used, but, because of the need for large sample weights and the desirability of an overnight precipitation period, these methods are not ideal. Furthermore, to increase the accuracy of the phosphate method, it is advisable to process a synthetic alloy solution to provide an empirical factor. Although mandelic acid does not suffer from this disadvantage, the high cost of this reagent makes its use uneconomical where large batches are concerned.

In view of the above, attention was turned to possible photometric methods using alizarin-S which has already been applied successfully to the determination of zirconium in magnesium alloys. [1] For the latter, the alloy is dissolved in dilute hydrochloric acid, the acidity adjusted and the colour developed under carefully controlled conditions of time and temperature.

To enable a similar technique to be used for aluminium alloys, it was necessary to investigate the following.

(*a*) The choice and control of the acid or alkali for solution of the alloy and the acidity for subsequent colour development.

(*b*) The possibility of the presence of insoluble zirconium compounds in the solution media.

(*c*) The interfering effects of the base element aluminium, the other alloying elements, and impurities (e.g. iron, silicon, magnesium) on the coloured zirconium complex.

Initial experiments confirmed that the acidity conditions described by Mayer and Bradshaw[1] were suitable for colour development, but it was found preferable to immerse the sample in a boiling water bath for 5–6 minutes, to ensure that the maximum colour was developed under routine control conditions.

Dissolution Techniques

To facilitate the removal of the bulk of the aluminium, an alkaline separation was tried first. After dissolution of the alloy in sodium hydroxide, with or without addition of sodium carbonate or sodium peroxide, the zirconium hydroxide precipitate was coagulated by the addition of magnesium solution. The combined precipitate was separated from the sodium aluminate solution by means of a centrifuge, and then dissolved in hydrochloric acid alone or hydrochloric acid-bromine mixtures.

Good results were obtained only when prolonged boiling was used to remove the last traces of bromine. Because of this difficulty, erratic results were often obtained under routine-control conditions.

The direct solution of the sample in hydrochloric acid, with subsequent adjustment of the acidity, was reverted to, and it was found that the results were of a consistent nature and in good agreement with the sodium hydroxide method.

Additions of oxidizing agents such as bromine, hydrogen peroxide or perchloric acid were made to aid rapid, complete solution of the copper in the hydrochloric acid. No advantage was gained, and under certain circumstances hydrolysis of the zirconium took place.

Tests for Insoluble Zirconium Compounds

It was evident that the solution of the alloy in hydrochloric acid alone was the best procedure, but the possibility of the presence of insoluble zirconium compounds had to be considered. This was investigated briefly as follows :—

Large sample weights were dissolved in dilute hydrochloric acid according to the conditions specified in the final method. The insoluble siliceous matter was filtered off, washed thoroughly, ignited at low temperature and examined chemically and spectrographically for the presence of zirconium. No zirconium was detected chemically and an insignificant amount ($<0{\cdot}005\%$) was shown up spectrographically.

In addition, typical samples were processed by the final method. The insoluble siliceous material was separated, ignited, treated with hydrofluoric acid, and the residue dissolved by fusion with a controlled amount of potassium bisulphate and added to the main solution prior to colour development. This treatment gave no significant increase (less than 0·005%) in the percentage zirconium obtained.

The use of added sodium flouride to ensure complete solution of all zirconium compounds, followed by complexing excess flouride with boric acid, was tried, but it resulted in bleaching of the zirconium lake.

Interference by Other Elements

Tests on pure aluminium and typical Hiduminium RR.250 alloys (i.e. Hiduminium RR.350 not containing zirconium) showed that, under the specified conditions, pure aluminium gave an extinction value of 0·02 when the zero was set at 0·80 on the reagent blank. The complex alloy gave the slightly higher value of 0·03.

Using a range of Hiduminium RR.250 alloys covering the element contents given below, the extinction values showed a spread of only 0·01 and the same recovery of zirconium was obtained when aliquots of a standard zirconium oxychloride solution, up to 0·4% zirconium, were added to the solution of each alloy.

Copper	4·0–6·0%
Nickel	0·7–2·0%
Iron	0·2–0·6%
Silicon	0·1–0·4%
Manganese	0·1–0·4%
Titanium	0·1–0·25%
Cobalt	0·1–0·4%
Antimony	0·1–0·4%
Magnesium	0·1%

Elements present within the above ranges had no significant effect on the extinction values, and by zero setting on a processed sample of a zirconium-free alloy of the same type (e.g., Hiduminium RR.250) blank effects can be reduced to negligible proportions. Aliquots of this zirconium-free alloy can also be used for calibration purposes by the addition of suitable aliquots of zirconium oxychloride solution.

The Method

Reagents

Hydrochloric Acid : (*a*) Concentrated (11·3N);(*b*) 20% v/v solution.

Sodium Carbonate : 1·13N solution.

Indicator Solution: Bromo-phenol-blue.

Alizarin-S (*Sodium Alizarin Sulphonate*) : 0·15% w/v filtered solution.

Zirconium Oxychloride Solution : A standard solution is prepared in very dilute* hydrochloric acid so that 10 ml. = 0·3% zirconium on a final aliquot of 0·15 g.

Procedure

Weigh 1·5 g. of sample into a conical beaker, cover with 15 ml. of water and add 15 ml. of concentrated hydrochloric acid. Cover the beaker with a watch glass and allow to stand in cold water until the violent reaction has ceased. Add a further 30 ml. of acid, wash down the inside of the beaker with water and transfer to the hot-plate. Heat for 15 minutes, during which time the sample should be boiling for about 10 minutes. If necessary, any particles adhering to the walls of the beaker may be washed down with water prior to the boiling period. Cool the sample, transfer to a 100 ml. graduated flask, dilute to the mark and mix. Allow the slight copper precipitate to settle, or in the event of a noticeable cloudiness persisting after 5–10 minutes (e.g. 0·4% silicon) filter off approximately 30 ml. of the solution through a small dry Whatmans No. 541 filter paper into a dry beaker. Pipette 10 ml. of the sample into the original beaker, and a second 10 ml. aliquot into a suitable centrifuge tube, tall beaker or boiling tube.

To the 10 ml. aliquot in the original beaker, add bromo-phenol blue indicator, dilute slightly and titrate with the standard sodium carbonate solution to the blue end-point. This titration value divided by 10 gives the number millilitres of 11·3 N hydrochloric acid present in the aliquot, and 3·00 minus this figure gives the addition of acid required. (A titre value of 22–28 ml. is normal, thus necessitating the addition of 0·8–0·2 ml. of concentrated acid to the aliquot.)

To the second aliquot, add the determined volume of hydrochloric acid from a burette and dilute to 25 ml. with water. Mix thoroughly by shaking gently and transfer the tube to a boiling-water bath for five minutes. Cool rapidly, transfer to a 100 ml. graduated flask containing 10 ml. of 20% v/v hydrochloric acid, dilute to the mark and mix. Measure the extinction value of the solution using the Spekker Absorptiometer (Model H 760) with a tungsten filament lamp, 3 cm. cells, Ilford yellow-green, No. 605 filters and a zero setting of 0·80 on a processed zirconium-free alloy sample (i.e. Hiduminium RR.250).

Calibration

Process standard samples by the above procedure or, if not available, make suitable additions of the standard zirconium solution to aliquots of the blank-setting sample, adjusting the final acidity to be the same as in the samples.

General Observations

Using the above method under routine conditions, it is possible to carry out 12 determinations in three hours.

The percentage standard deviation (coefficient of variation) on a batch of 10 samples of an alloy containing 0·2% zirconium, was less than 1, indicating a high degree of reproducibility. Agreement on single sample determinations from batch to batch was within ± 0·01% zirconium over the content range of 0·1–0·4%.

Table I shows that good agreement was obtained between this method and our alternative gravimetric and spectrographic methods.

TABLE I.

Sample	Zirconium Found %		
	Photometric	Gravimetric	Spectrographic
A	0·09	0·10	0·09
B	0·18	0·18	0·17
C	0·21	0·21	0·22
D	0·25	0·24	0·25
E	0·24	0·25	0·24
F	0·28	0·27	0·27
G	0·30	0·27	0·29
H*	0·54	0·52	—
I*	0·60	0·61	—

* Half sample weights were employed.

In a series of 60 typical samples analysed by the photometric and spectrographic methods, the maximum divergence of results was 0·03%, and this in the case of three samples only. Where gravimetric determinations were also carried out the agreement was of the same order.

The calibration curve showed only slight variation over a period of time and the maximum " shift " recorded was equivalent to 0·02% zirconium on a 0·4% content. The final coloured solution was found to be stable over a period of at least 1½ hours under normal laboratory conditions.

The above photometric method, using alizarin-S, has been found successful for foundry control purposes, and preliminary results have shown that the same method, with suitable modification of the sample weight and solution technique, can be conveniently applied to the determination of zirconium in pure aluminium.

Acknowledgment

The authors wish to thank the Directors of High Duty Alloys, Limited, in whose Research Laboratories the method was developed, for permission to publish this article.

REFERENCE

1 Mayer, A., and Bradshaw, G., *Analyst*, 1952, **77**, 476–483.

* The acidity of this solution must be known and allowed for in the calibration standards.

Improved Determination of Carbon in Metals

G.E.C. Conductimetric Equipment

THE determination of carbon in a large variety of ferrous and non-ferrous metals and alloys is called for in connection with many industrial processes. The range of samples may include various types of iron and steel, nickel, and alloys containing chromium, cobalt, tungsten, nickel and titanium. Carbon analyses may also be required on irons and steels before and after various experimental carburising and decarburising treatments.

An additional requirement in recent years has been the accurate determination of very low carbon contents in certain ferrous materials used for electrical purposes. In iron-silicon alloys for example, the hysteresis losses increase rapidly with increasing carbon content, and a maximum of 0·05% is permissible. Similarly, with pure iron, interesting and useful magnetic properties are obtained with less than 0·01% carbon. The determination of carbon in these materials calls for an accuracy of at least three places of decimals, and the two techniques in fairly common use for the determination of very low carbon contents both have certain disadvantages. One of these techniques the "low pressure" method, relies on the condensation in a liquid oxygen trap of the carbon dioxide formed by combustion of the carbon in the sample. The gas is then expanded into an evacuated vessel of known volume and its pressure measured. This is a fairly rapid and very accurate method but is complicated and inconvenient for occasional use.

The second method uses the normal process, whereby the carbon dioxide produced by combustion is absorbed and weighed, but the extra sensitivity required is obtained by an increase in sample size. Such large samples (10–20 g.) are easily obtained in a steel works but are seldom available in research investigations.

A third method, which has been less commonly used, involves the electrical conductimetric determination of the carbon dioxide produced in the combustion of a sample of normal size (1–2 g.). This method has recently been further developed in the Research Laboratories of The General Electric Co. Ltd. and, after a number of modifications, has been found to fulfil all the present requirements.

Purified oxygen is supplied at a controlled rate to a mullite combustion tube containing the specimen in an aluminous porcelain boat. The combustion tube temperature varies between 1100° and 1300° C., depending on the material to be analysed. A special loading device permits the boat to be pushed into the hot zone of the furnace, without the entry of air, after the combustion tube has been swept out with pure oxygen. The gases leaving the combustion tube are passed through granular manganese dioxide to remove oxides of sulphur and thence into the specially designed Perspex conductivity cell (Fig. 1). This contains a solution of caustic soda or barium hydroxide at a thermostatically controlled temperature, together with a trace of a non-ionic wetting agent.

The gas bubbles formed are made to follow a helical path about 55 in. in length, which ensures efficient absorption of the carbon dioxide. The solution circulates to the electrode chamber in the centre of the cell, and the conductivity is determined by means of a Wheatstone bridge circuit using a 50 c/s A.C. supply and a vibration galvanometer for null indication. A major virtue of this method of determining carbon content is that the conductivity can be measured at any moment without stopping the flow of oxygen. This enables the operator to be perfectly sure when evolution of carbon dioxide ceases. The measuring cell itself contains only 45 ml. of solution, which gives high sensitivity, and is robust and very easily emptied and refilled. The conductimetric method also has the advantage of wide range, so that high-carbon cast irons can also be analysed.

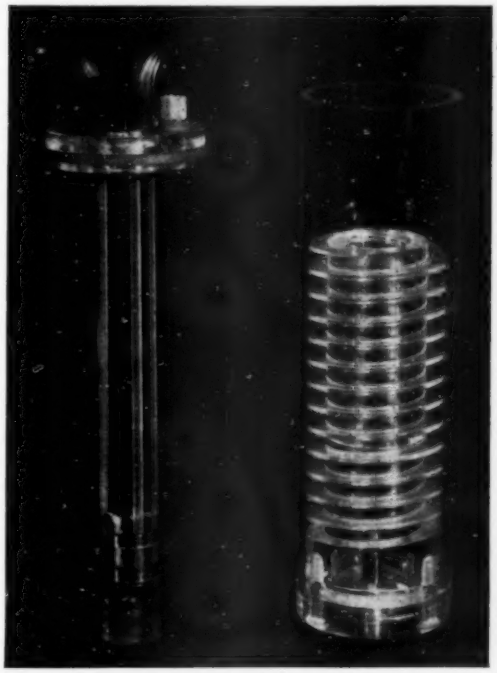


Fig. 1.—The Perspex conductivity cell for the conductimetric determination of carbon in metals; left: lid and central portion showing platinum electrodes and gas passages; right: body and base of cell, incorporating helical gas bubble passage.

Combustion of cast irons, iron powders, and plain carbon steels is complete and sufficiently rapid, without the use of fluxing or igniting materials. With all other alloys so far analysed, either lead or tin or both these metals have been found to be useful additives which do not introduce large errors. Lead is useful for iron-rich alloys and acts primarily as a flux. Tin acts mainly as an igniter and is most useful for alloys containing large amounts of nickel, cobalt or tungsten; with high-nickel alloys tin has an additional fluxing effect.

The results shown in the following table were obtained on two standard steels and one standard cast iron from the Bureau of Analysed Samples Ltd.

Carbon Present (according to B.A.S.)		Carbon Determined by Conductimetric Method
Average %	Range %	%
0·029	0·0275–0·032	0·0289, 0·0283, 0·0283 0·285
0·365	0·360–0·370	0·361, 0·363, 0·363, 0·362
2·88	2·83–2·93	2·90, 2·89, 2·88, 2·89

These determinations were made on 0·5 g. and 1·0 g samples with caustic soda solution in the cell, and no result has been discarded. On low-carbon samples containing 0·01% carbon, duplicate analyses agree within 0·001% and usually between 0·0002% and 0·0003%. Sample weights have varied from 0·1 g. to 3·0 g. and close agreement has always been obtained when results have been checked by independent gravimetric determinations.

Use of Electrolytic Apparatus for Identification of Alloys

By C. Goldberg

New England Smelting Works, Inc., West Springfield, Mass.

ELECTROLYTIC apparatus is commonly used in the non-ferrous control laboratory for the quantitative electro-deposition of various metals, especially copper and lead. The purpose of this note is to indicate how the same apparatus may be utilised for the rapid identification of constituents of certain alloys, or to give a rough approximation of the percentage of an element present. The procedures recommended are based upon long experience in the author's laboratory.

Zinc in Aluminium Alloys.—To determine whether or not a certain aluminium alloy contains a relatively high zinc content, it is sufficient to dissolve 1 g. of the sample in the usual manner in caustic soda solution, dilute with distilled water and electrolyze at 2 amp., using a copper-plated cathode. One per cent. or more of zinc is easily seen as the silvery metal.

Manganese in Manganese Bronze or Manganese Copper.—The anodic oxidation of manganese to purple permanganic acid may be used to identify the sample as manganese bronze, if the manganese content is sufficiently high, or to indicate that the sample is manganese copper (10–50% manganese). A 1 g. sample is dissolved in 10 ml. of 50% c.p. nitric acid solution and diluted to 100 ml. with distilled water. The solution is electrolyzed at 5 amp., without stirring. If there is 0·25% manganese or more present, the purple colour of permanganic acid will be seen at the anode. If the sample is manganese copper the purple colour will rapidly spread through the entire solution. A considerable saving of the expensive silver nitrate or potassium periodate may be made in that way.

Lead in Brass, Bronze, Babbitt, Zinc, etc.—The well known electro-deposition of lead as lead peroxide from nitric acid solution may be used to ascertain the presence or absence of lead in many alloys. In a volume of 150 ml. containing 10 ml. of 50% c.p. nitric acid and at 5 amp., with stirring, as little as 0·2% of a 1 g. sample may be detected after 5 minutes. If it is thought that lead is present, though less than 0·20%, dissolve 10 g. in nitric acid solution, neutralise with ammonium hydroxide, make just acid with nitric acid and add 5 ml. in excess. Dilute to 150 ml. with distilled water and electrolyze. 0·02% lead may be shown in this way.

Approximate Percentage of Iron in Iron-Copper Mixtures.—When iron and copper mixtures are submitted for chemical analysis, it is useful to start by obtaining an approximate idea of the iron content. For that purpose 1 g. is dissolved in 10 ml. of 50% c.p. nitric acid, diluted with distilled water to 100 ml. and electrolyzed at 5 amp. After a few minutes the cathode is examined. If the iron content is greater than 70%, copper will be evident only at the rim of the cathode, if at all, because of the solvent action of ferric iron upon copper.

Removal of Copper Previous to Tests.—The electrolytic apparatus is very useful for rapidly removing small amounts of copper or copper and lead before testing for the presence of such elements as beryllium, aluminium, iron, nickel or zinc. A 0·1 g. sample is dissolved in 10 ml. of 50% c.p. nitric acid and diluted with distilled water to 100 ml. It is electrolyzed with stirring, for ten minutes and the usual tests for the above mentioned elements made upon the filtrate.

Traces of Copper in Nickel.—The presence or absence of more than a trace of copper in nickel is easily and quickly ascertained by electrolysis from nitric acid solution. As little as 0·1% (1 g. sample) of copper is noticeable if the current is reversed so that the copper is deposited upon the smaller electrode.

Documentation of Applied Chemistry

The First International Congress on Documentation of Applied Chemistry will be held in London from the 23rd to 25th November, 1955, under the patronage of the International Union of Pure and Applied Chemistry. It is sponsored by the Society of Chemical Industry and has as President of Honour The Rt. Hon. Lord Cherwell, C.H., F.R.S. The Chairman of Council is Sir William Ogg, M.A., Ph.D., LL.D., Director of Rothamsted Experimental Station. An Organising Committee has been set up with Dr. L. H. Lampitt as Chairman and Dr. A. King as Deputy Chairman. Dr. D. W. Kent-Jones is Honorary Treasurer and Lt.-Col. F. J. Griffin is the Honorary Secretary.

Membership of the Congress is open to all interested persons on payment of the membership fee of £2 2s. It is hoped to issue the detailed programme in the near future and all enquiries should be addressed to the Honorary Secretary, International Congress on Documentation of Applied Chemistry, 56, Victoria Street, London, S.W.1.

An Improved Method for the Taper Sectioning of Metallographic Specimens

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A method has been developed for the taper sectioning of standard metallographic mounts by the use of a simple machining jig. An accurate method of measuring the taper ratio of the finish-polished section has also been devised in which a reference wire is buried in the protective electrodeposit on the specimen surface and is sectioned with the specimen ; from measurements of the major dimensions of the section of the wire the taper ratio of the section can be determined.

THE principle of the vertical enlargement of the surface topography of metallographic specimens by taper sectioning is an obvious one, but the first published account of the method appears to be that of Nelson[1]. Nelson formed the taper by tilting the specimen on the table of a surface grinding machine, thus grinding the section surface at the required taper angle to the original surface ; for this purpose, the specimen, which had been prepared with parallel faces and with the required surface protected by means of a heavy electrodeposit, was set on a wedge block.

Subsequent developments in sectioning methods have been along entirely different lines. The general principle has been to mount the specimen in a plastic cylinder in which a taper angle relative to the specimen surface has been established on one transverse face ; subsequent surface grinding parallel to this taper face transfers the taper to the specimen. Moore[2], and Norris[3] formed the taper in the specimen mount by using a special follower in the mounting die. Perryman[4] rested the specimen on a pre-formed wedge of plastic on to which a normal mount was formed. Davis and Hoare[5] developed a special technique for thin sheet in which the taper angle was ground into the top surface of a blank mount ; the specimen was then attached to the taper surface.

All these techniques overlook the simplicity of methods based on the use of a machining jig, as in Nelson's original technique. Nelson's method itself is unsuitable for metallographic specimens, which are usually required in a plastic mount, and, in any case, is only applicable to magnetic materials. A machining jig suitable for standard metallographic mounts can, however, be readily constructed.

Method of Sectioning Using a Machining Jig

A suitable jig has been developed, consisting essentially of a steel block in which a hole has been bored at the required taper angle (5° 43′ for a 10 : 1 taper ratio) ; the hole is reamed to a good fit for the size of specimen mount in use, and the block is partly split so that the mount can be clamped firmly in position. The jig is set up in a surface grinding machine, as illustrated in Fig. 1, and the taper-section surface ground on the mount and specimen. The specimen is then broken out of the mount and is re-mounted with the taper section surface coincident with the bottom face of the new mount. Alternatively, the taper-section surface can be prepared by turning, the jig then being held in a four-jaw chuck in a lathe. This may be an important advantage in some cases, since it has been found that the depth of deformation produced in the surface by turning is considerably less than that produced under optimum conditions of surface grinding.

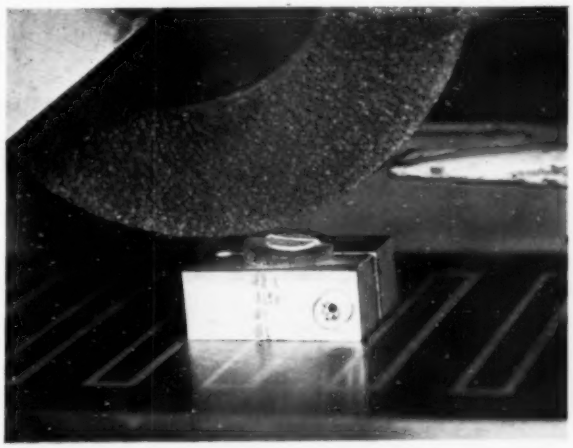

Fig. 1.—Specimen clamped in machining jig for surface grinding.

The main advantage of the method is that a standard specimen mount is used. Any mounted specimen may, therefore, be sectioned without special prior preparation. If the mount is a good fit in the jig, the taper angle will be accurately reproduced and, by rotation of the mount in the jig, the section can be prepared with the section line in any desired direction. The method produces an obtuse-angled section which, as noted by Norris[3], and by Davis and Hoare[5], makes the sharp retention of the section line during polishing much easier than in the case of an acute-angled section.

Measurement of Taper Angle

Because of the smallness of the angle for a 10 : 1 taper ratio, small errors in angle result in relatively large departures from the nominal taper ratio (for example, an error of only 0° 3′ in the angle changes the taper ratio by as much as 1%).

Moore[2] realised that it was not sufficient to assume that the intended taper angle had been produced during machining, and devised a method of measuring the actual taper angle by the use of an optical goniometer. This method requires that the specimen be mounted in transparent plastic which, in general, is not as satisfactory for metallographic purposes as the harder bakelite types.

The taper angle of specimens sectioned as described

above can be determined by measuring the angle between the newly machined taper-section surface and the remaining portion of the original surface of the mount. This angle can be measured by means of a profilometer or by a projection method, but, as in the case of Moore's method, special equipment is required which is generally not readily available in metallographic laboratories.

The most serious disadvantage of measuring methods of the above types, however, is that the angle measured is that of the as-machined or, at best, partly-prepared surface; the assumption is made that the finish-polished surface is strictly parallel to this surface. Even with the most skilled handling on abrasive papers, however, some tilting of the specimen is unavoidable and in practice it was found that the change in taper ratio from this source frequently amounted to 10% or more.

In the method to be described, these difficulties are eliminated by the use of an internal calibration standard incorporated in the mount with the specimen. Further, the method does not require special measuring equipment, is simple and rapid, and the taper ratio can be determined directly at any stage of the preparation. The particular example quoted is a copper base alloy.

Slits are cut in the original specimen mount and a length of fine-gauge copper wire, previously checked for circularity in cross-section, is secured in the slits such that a straight length of wire is stretched close to and parallel to the surface of the specimen (see Fig. 2); a wire of about 35 s.w.g. is suitable for a 10 : 1 taper ratio. The reference wire is arranged with its axis perpendicular to the intended taper-section line. A heavy electrodeposit of copper is then formed on the specimen surface in the usual way so that the reference wire is buried in the deposit, as in Fig. 2. The specimen is then taper sectioned and prepared for examination.

The taper section will include an elliptical section of the reference wire (see Fig. 3). If the major axis of this ellipse is perpendicular to the section line, the ratio of the major to the minor axis is the true taper ratio of the section. The major axis usually will not be strictly perpendicular to the section line; in this event, the distance between the tangents to the ellipse parallel to the taper-section line is measured instead of the major axis; the ratio of this distance to the minor axis of the ellipse is the true taper ratio of the section. The taper ratio can be determined to an accuracy of approximately ± 1% using standard metallographic measuring equipment. The other factor which determines the overall accuracy of the method is the degree of parallelism between the reference wire and the original surface. If a little care is taken in positioning the wire, it is easily possible to ensure that the error due to this factor is also kept below 1%.

Fig. 2.—Specimen at left has reference wire secured in position. Specimen at right has been electroplated; wire is buried in the deposit.

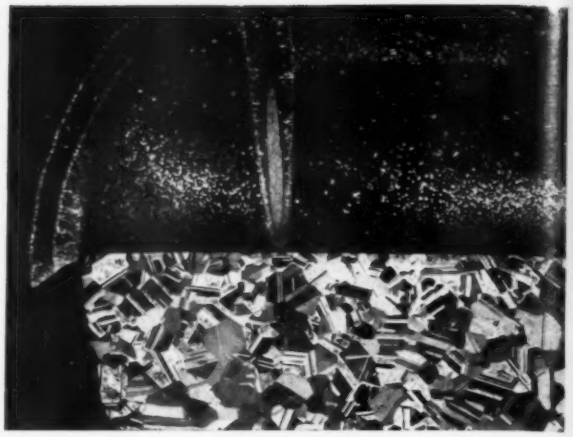

Fig. 3.—Taper-section surface, showing elliptical section of reference wire in the copper electrodeposit. Measurements of the axes of the ellipse give the true taper ratio of the section.

The main practical difficulty with the method is in retaining the reference wire in the electrodeposit. Since the adhesion between the electrodeposit formed on the wire and that formed on the specimen surface is largely mechanical, the wire shows some tendency to pull out during the machining of the section. Only a little care is required, however, to prevent this occurring. Once the section has been successfully machined, even a poorly adherent wire can be retained during metallographic preparation. The author has experience with copper-alloy specimens only, using copper reference wires and copper electrodeposits, but this experience would indicate that no serious difficulties are likely to arise with other combinations.

Acknowledgments

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REFERENCES

1 Nelson, H. R., Summer Conference on Friction and Surface Finish, M.I.T., 1940, p. 217.
2 Moore, A. J. W., *Metallurgia*, Manchr., 1948, **38**, 71.
3 Norris, D. J., C.S.I.R. Division of Aeronautics (Australia), Structures and Materials Note 166, 1948.
4 Perryman, E. C. W., *Metal Ind.*, Lond., 1950, **79**, 23.
5 Davis, J. E., and Moare, W. E., *J. Iron Steel Inst.*, 1951, **168**, 134.

Vacuum Furnace for B.C.I.R.A.

CEREMONIES commemorating the shipment of its 100th commercial-sized vacuum furnace were held at National Research Corporation on January 18th when Massachusetts Governor Christian A. Herter presented to Mr. William Barker, British Consul-General in Boston, a plaque marking the shipment of this furnace to the British Cast-Iron Research Association.